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Developed by teacher educators and agricultural engineers and tested by vocational agriculture teachers, this reference is for student and teacher use as part of a course on servicing and operating an engine. Content includes: (1) Distinguishing Features of Small Engines, (2) How Small Gasoline Engines Work, (3) Comparing 4-(Stroke)Cycle and 2-(Stroke)Cycle Engines, (4) Importance of Proper Care and Operation, (5) Identifying Types of Small Engines, (6) Cleaning Small Engines, (7) Servicing Carburetor Air Cleaners, (8) Servicing Fuel Strainers, (9) Servicing Crankcase Breathers (4-Cycle Engines), (10) Lubricating Small Engines, (11) Refueling Small Engines, (12) Servicing Spark Plugs, (13) Checking and Adjustment Carburetors, (14) Checking Compression, (15) Checking and Servicing Batteries, (16) Starting Engines, (17) Operating Engines, and (18) Storing Engines. Teachers should be graduates in teacher education and students should have mechanical and science interests and be of at least high school age. Supplementary materials include 168 colored illustrations, a list of references and an owner's engine information form. Volume II of this series contains information concerning major maintenance and repair of small engines and is available as VT 006 290. (DM)

SMALL ENGINES

CARE-OPERATION-MAINTENANCE & REPAIR

VOLUME I

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SMALL ENGINES

CARE-OPERATION-MAINTENANCE & REPAIR

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AMERICAN ASSOCIATION FOR AGRICULTURAL ENGINEERING AND VOCATIONAL AGRICULTURE

an organization of agricultural colleges and divisions of vocational agriculture devoted to the improvement of agriculture through better information and teaching aids.

Prepared by J. Howard Turner, Engineering Editor, and George W. Smith Jr., Art Director and Mrs. Florence Gorham, Illustrator of the American Association for Agricultural Engineering and Vocational Agriculture. Acknowledgement is given to the many individuals, companies and agencies that assisted, page 152.

JUNE 1968

VOLUME I

OF TWO VOLUMES

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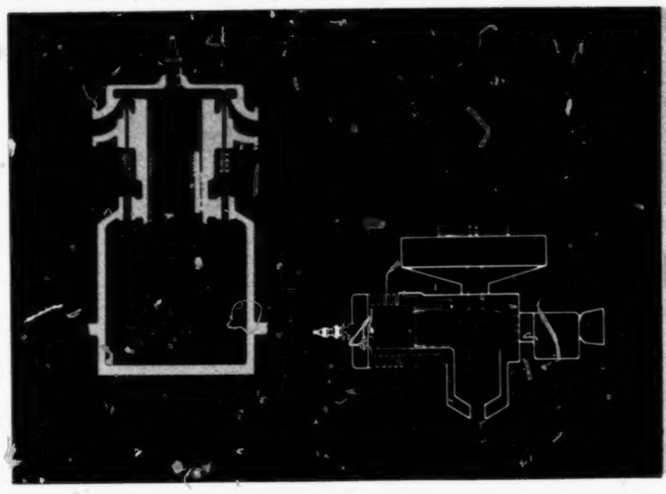

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SMALL ENGINES

CARE-OPERATION-MAINTENANCE & REPAIR

The purpose of this book is to help you to gain a practical working knowledge of small gasoline engines. For convenience it is bound in **two separate volumes.** If you are primarily concerned with understanding *how to service and operate an engine,* you will be more interested in the information given in **Volume I.** It deals with information which every owner or operator of a small engine should know. You will learn why certain accessories, such as carburetor air cleaners, crankcase breathers, and storage batteries, require frequent servicing; and how to service them. Procedures are given for other routine service jobs such as lubricating and refueling. What happens if they are neglected or are not serviced properly is also discussed.

You will learn how to operate your engine for maximum power and efficiency. Answers are given to such problems as the following: what to do if the engine will not start, if it loses power, or if it runs rough. When maintenance and repair jobs are needed, references are given for procedures which may be found in Volume II.

Volume II is for *those who wish to expand their knowledge beyond servicing and operating an engine* into *major maintenance and repair.* It explains the operating principles of different units such as starters, ignition systems, valves, and lubricaion systems. It also explains how to tell when such units are not working properly and how to repair them. The principles and procedures are given for each unit in such a sequence that it is not necessary for you to completely disassemble the engine before you start to work on it.

It is important that you understand that small engines, as discussed in both volumes, are the gasoline-powered, single-cylinder, air-cooled, spark-ignition types. They range in power from one-half horsepower to approximately 15 horsepower.

It is estimated that 70,000,000 small engines are now in use in the United States. This is testimony enough that they are filling a great need — one that is not being met adequately by other sources of power. Indications are that this number will increase substantially in the years ahead.

In spite of the popularity of small engines, they are often criticized. This is frequently due to lack of understanding of how engines work. For example, what do you think when your small engine will not start?

- That hard starting is typical of small engines, so you might as well accept it?
- That it is the make of engine, and you will never purchase that brand again?
- That the engine is worn out, although it is relatively new?

Then when you take your engine to the service shop, you usually find that a simple adjustment, or minor repair, will get it going again.

Most criticisms of small engines are unfounded. **The troubles engines give are generally due to lack of proper service, operation, maintenance, or repair.** They are really tougher than most people think. You usually find good reasons for engines giving occasional trouble if you examine the conditions under which they operate. For example:

- Most small engines are designed to operate continuously at or near top speed to prevent overload. Yet you would not think of operating your automobile engine at top speed all the time.

The speed of a small engine when it is operating at 3600 r.p.m. is equivalent to the speed of an automobile engine when the automobile is traveling 82 miles per hour.[1]*

(A chain saw engine may turn as fast as 6000 to 8000 r.p.m.)

- Many small engines operate near the ground where dirt and dust are more likely to get into them — when the engines are not serviced properly — and cause rapid wear.
- Small engines during operation are subjected to much abuse such as overspeeding and overloading.
- Few small engines receive regular and proper servicing, or periodic maintenance such as that given to the engines in trucks and tractors.
- Small engines are often repaired by poorly trained mechanics who are unable to diagnose troubles and to correct them properly.

Once you learn how your engine works, how to operate and service it properly, and how to do simple maintenance and repair jobs, you will enjoy a sense of pride and satisfaction in owning and operating it.

What you learn by studying small engines gives you a basic understanding of larger multi-cyclinder engines. Regardless of the engine size, the principles are the same. Operation, maintenance, and repair procedures are very similar. Therefore, *if you understand how a small, single-cylinder engine works, you can apply your knowledge to large multi-cyclinder engines* such as those in tractors and automobiles.

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*Refer to numbered references starting on page 146.

VOLUME 1

CARE AND OPERATION OF SMALL GASOLINE ENGINES

How many small gasoline engines are in use around your own home, farm, or business?*

Perhaps you have counted the number of small engines in your neighborhood. If so, you were probably surprised at how many odd jobs are now being done by these sturdy little power plants.

Annual production in the United States of single-cylinder air-cooled engines is approximately 6,000,000 units. Mass production, coupled with ad-

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*A suggested engine inventory form, for individual use or class use, is shown on page 145 of the Appendix. When it is completed, it will be a convenient record to which you may refer when making repairs or ordering parts.

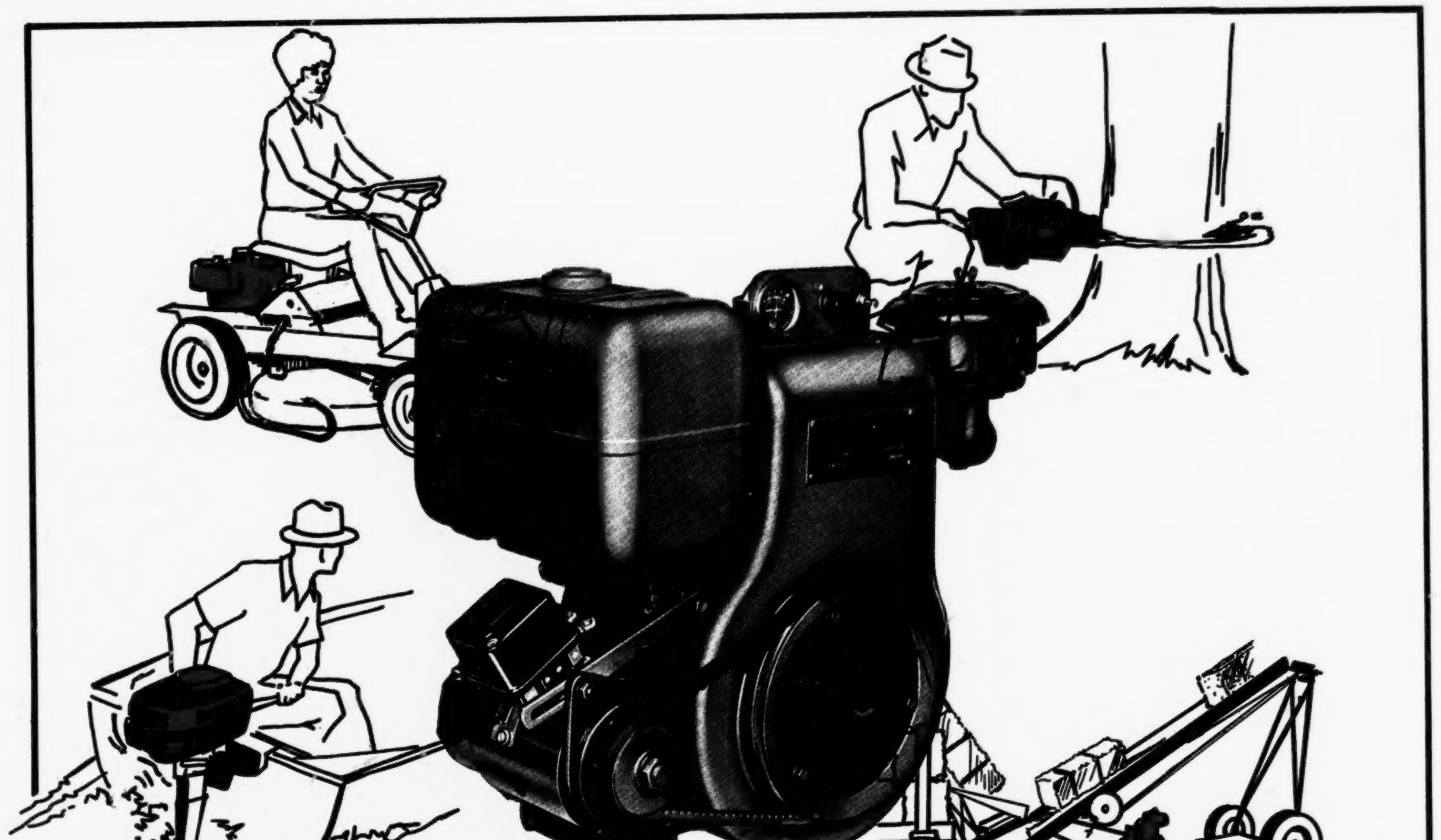


FIGURE 1. Small air-cooled gasoline engines are taking the drudgery out of many chores that were once done by hand.

vanced engineering, has helped to provide these useful engines at prices most everyone can afford.

Small engines are easily adapted to many small jobs because they are:

- Compact.
- Lightweight.
- Easy to service and repair.
- Air-cooled.
- Self-contained.

Some of the machines, or equipment, powered by small engines are the following:

Post-hole diggers
Irrigation pumps
Chain saws
Small tractors
Conveyors
Motorcycles
Snow blowers
Rotary tillers
Refrigerators
Bush cutters
Mowers
Lawn edgers
Outboard motors
Power bicycles
Air compressors
Sump pumps
Go-Karts
Mini-bikes
Ice augers
Sprayers
Small feed grinders
Elevators
Generators
Snow vehicles
Concrete vibrators
Concrete surfacers
Earth drills
Tillers
Golf carts

DISTINGUISHING FEATURES OF SMALL ENGINES

To meet the requirements for different types of equipment, small engines are made with many different features and in many different designs.

Aside from differences in size (horsepower) of small engines, most of the variations are in the accessories such as different types of starters, carburetors, and ignition systems. Cylinder blocks are made from aluminum or magnesium alloys, or from cast iron.

A major difference in the two most common types of small engines is in the number of strokes per cycle. This difference is explained under "How Small Gasoline Engines Work," page 10.

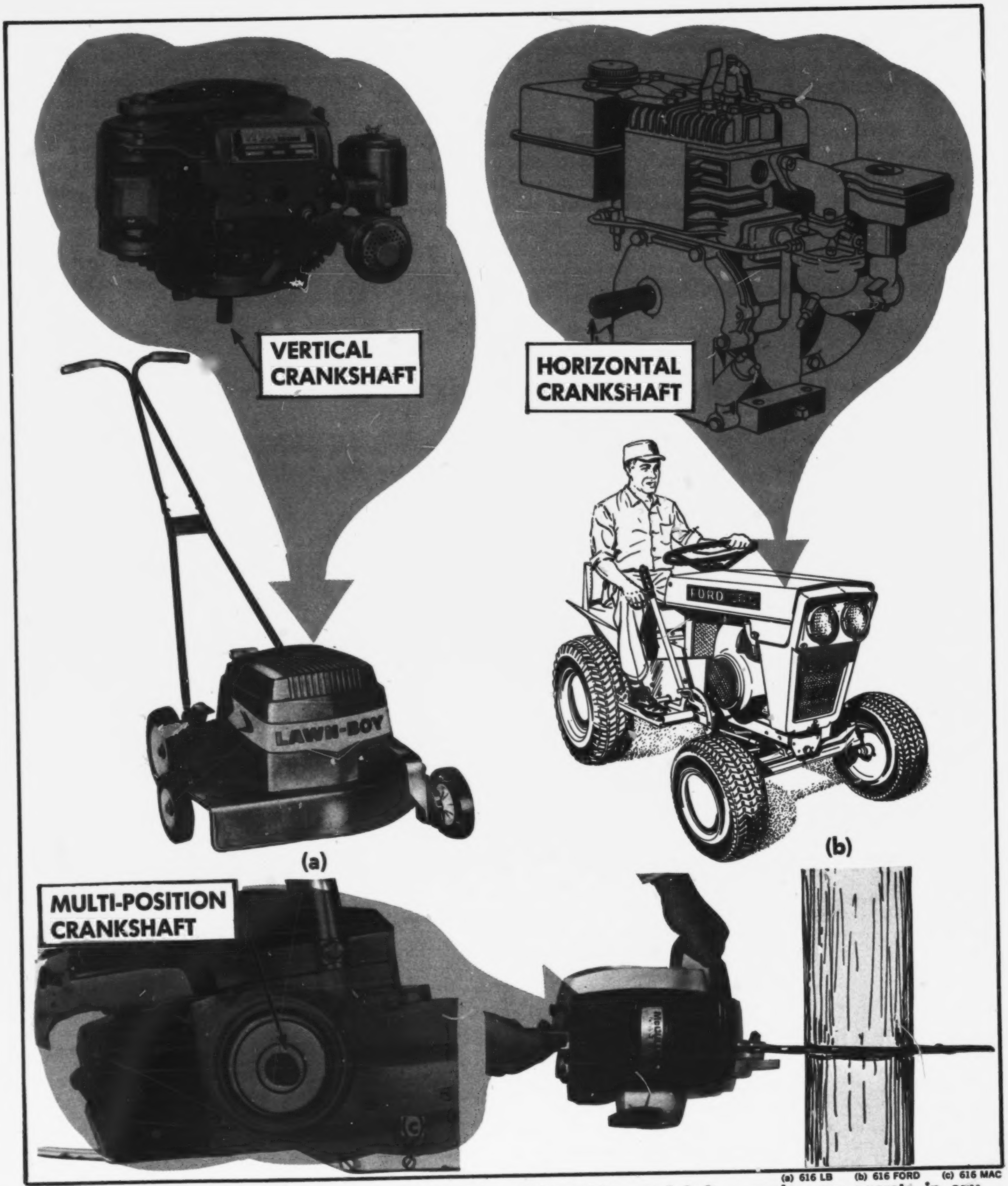
Most of these features you may not quickly recognize, even if you are experienced with engines; but you will become acquainted with them as you continue your study.

There is one distinguishing feature, however, that is easily seen on most engines: the *operating position of the crankshaft.* There are three basic operating positions:

1. Vertical (Figure 2a).
2. Horizontal (Figure 2b).
3. Multi-position (Figure 2c).

All crankshafts operate at a right angle to the cylinder. The selection of a vertical, a horizontal or a multi-purpose crankshaft engine, however, is determined by its adaptability to the equipment on which it is to be used.

A **vertical crankshaft engine** has its cylinder in a horizontal position (Figure 2a). The vertical crankshaft is well adapted to mounting a mower blade directly to the shaft. If a horizontal crank-


VERTICAL
CRANKSHAFT
HORIZONTAL
CRANKSHAFT
LAWN-BOY
FORD
(a)
(b)
MULTI-POSITION
CRANKSHAFT

(a) 616 LB (b) 616 FORD (c) 616 MAC

FIGURE 2. Operating positions of engine crankshafts. (a) Vertical crankshaft. (b) Horizontal crankshaft. (c) Multi-position crankshaft — engine can operate in any position.

shaft engine (Figure 2b) had been used, some type of right-angle drive would have been necessary to align the crankshaft with the mower blade.

A **horizontal crankshaft engine** may have its cylinder in a vertical, a horizontal, or an intermediate position. In Figure 2b the horizontal crankshaft engine is well adapted to supplying power to a horizontal transmission shaft. Such engines are often used on small tractors.

A **multi-position crankshaft engine** (Figure 2c) will operate in any position. Of course the piston is always at a right angle to the position of the crankshaft. This type of engine is used on chain saws and other applications where the position of operation may be at extreme angles, or even inverted (upside down). How this is possible is explained under "Comparing 4-(Stroke)-Cycle and 2-(Stroke)-Cycle Engines," page 15.

The crankshaft position may be your first clue as to the design features you may expect to find in an engine.

HOW SMALL GASOLINE ENGINES WORK

The small air-cooled gasoline engine is an "internal-combustion engine." All gasoline engines are known as *internal-combustion engines* because energy for driving the crankshaft is generated within the engine itself. This is accomplished by a fuel-and-air mixture igniting within a confined chamber (cylinder), expanding because of heat, and forcing a piston to move (Figure 3). The piston is connected to a crankshaft which changes the linear (straight-line) motion of the piston to rotary motion.

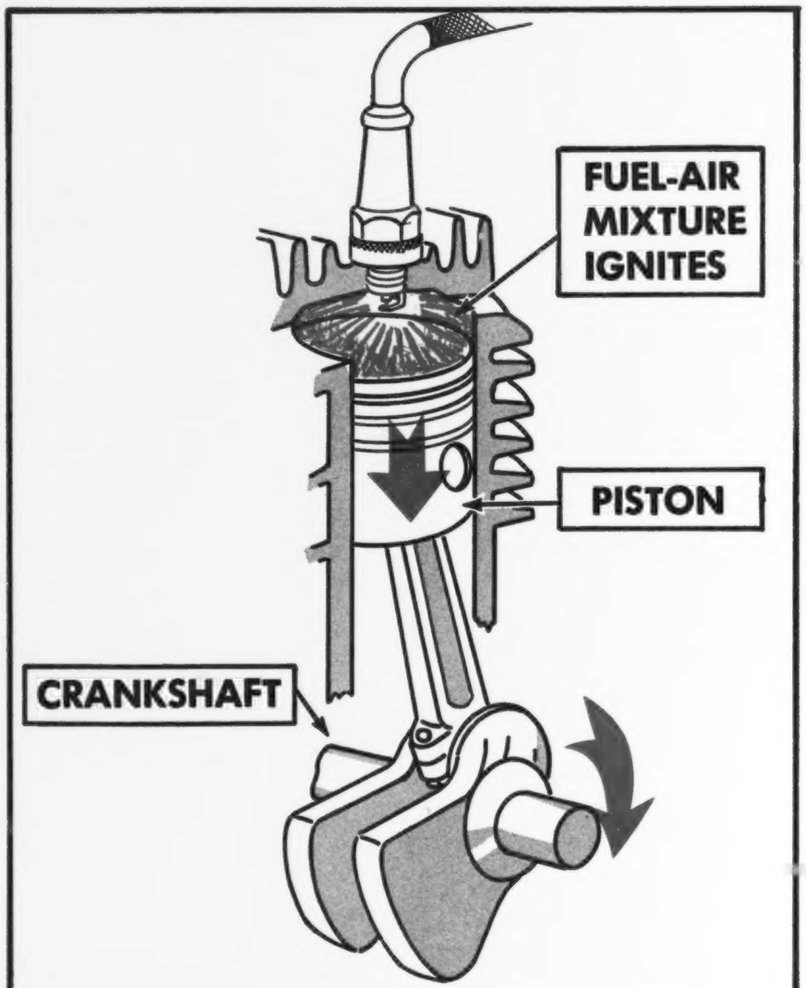


FIGURE 3. Basic principle of an internal-combustion engine. When the fuel-and-air mixture is confined in the cylinder and burned, the pressure of the expanding gases pushes the piston down. The up-and-down motion of the piston is converted into rotary motion by the crankshaft.

To make an engine run continuously, however, more has to happen than was previously described. In fact, with the types of internal combustion engines discussed in this book, *four principal events must take place.* The four events are as follows:

1. **Intake,** or suction of the fuel-air mixture into the cylinder (Figure 4a).
2. **Compression** of the fuel-air mixture (Figure 4b).
3. **Power** — ignition and expansion of the heated fuel-air mixture (Figure 4c).
4. **Exhaust** of burned gases (Figure 4d).

The *completion of this series of events* is called a **"cycle."** When the first cycle is completed, the second cycle starts, the third follows, and so on as long as the engine is kept running.

The *full travel of the piston in one direction* — either toward the crankshaft or away from the crankshaft — is called a **"stroke."**

Some small engines are designed to complete a cycle during one revolution of the crankshaft (two strokes of the piston). Others require two revolutions of the crankshaft (four strokes of the piston). Thus the names are as follows:

- Two-stroke cycle engine.
- Four-stroke cycle engine.

Since the 4-stroke cycle engine is easier to understand, it is discussed first.

Here is how a **4-stroke-cycle engine** works.

STROKE 1 — **Intake** (Figure 5a) — As the piston moves downward, away from the cylinder head:

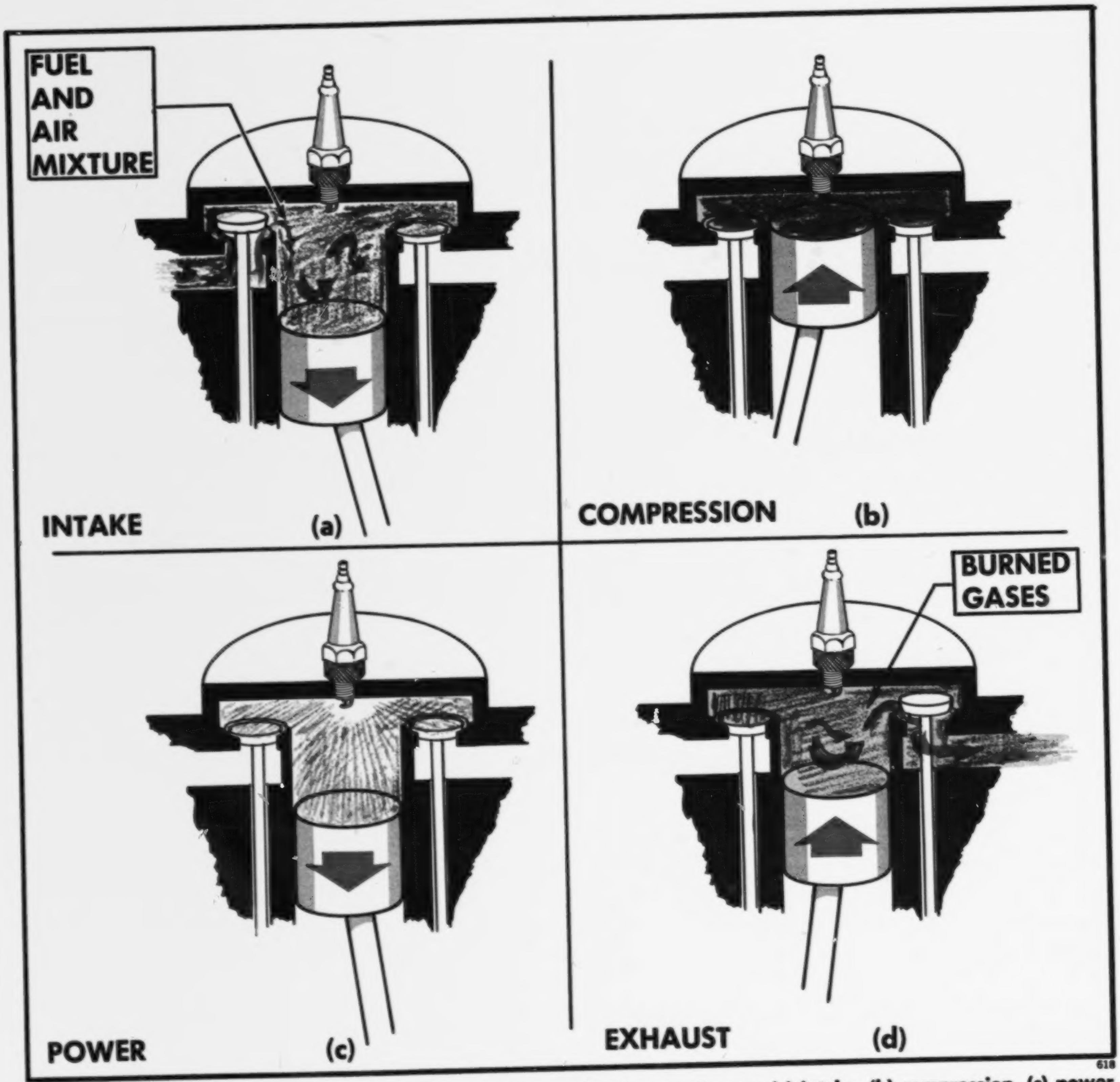
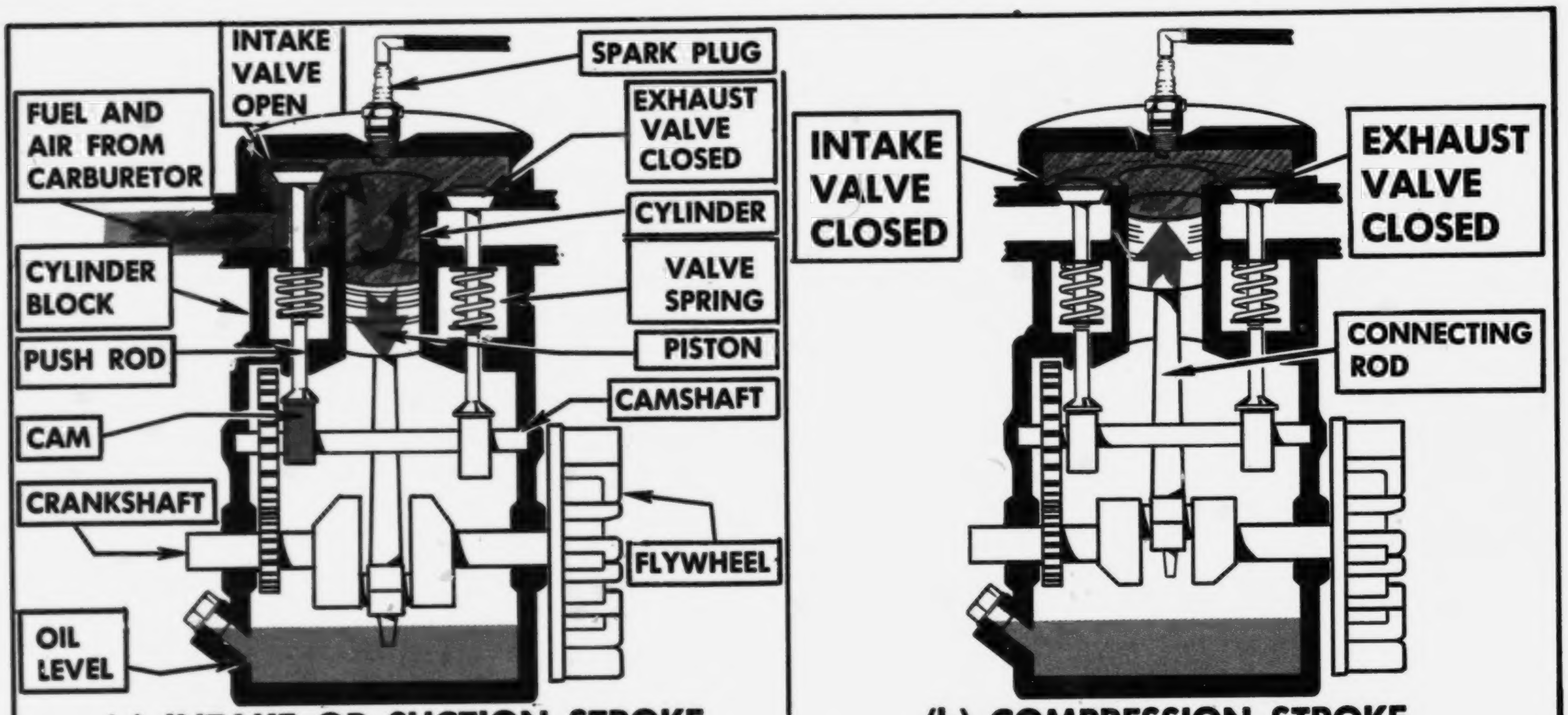

FUEL AND AIR MIXTURE
INTAKE
(a)
COMPRESSION
(b)
BURNED GASES
POWER
(c)
EXHAUST
(d)
618

FIGURE 4. The four principal events in the operating cycle of an engine are (a) intake, (b) compression, (c) power, and (d) exhaust.

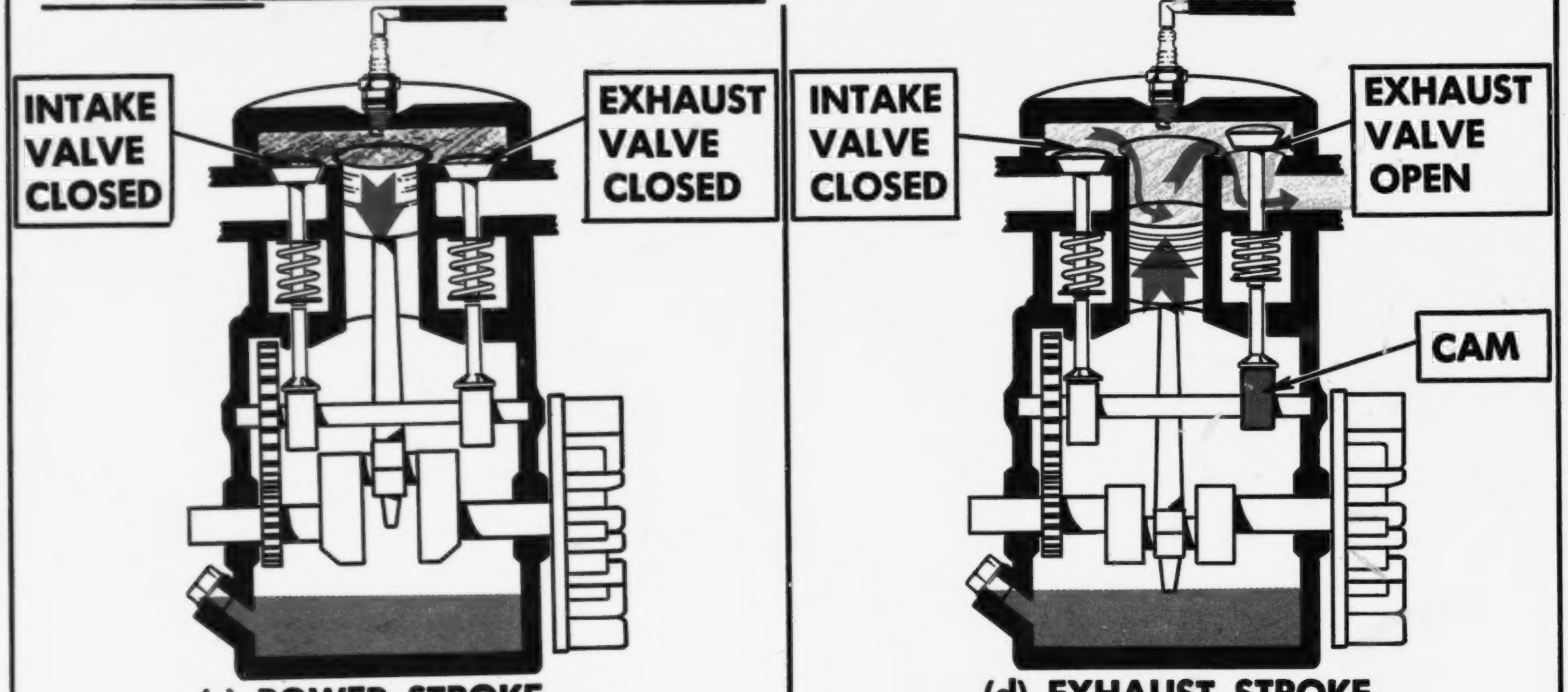

INTAKE VALVE OPEN
SPARK PLUG
FUEL AND AIR FROM CARBURETOR
EXHAUST VALVE CLOSED
CYLINDER
CYLINDER BLOCK
VALVE SPRING
PUSH ROD
PISTON
CAMSHAFT
CAM
CRANKSHAFT
FLYWHEEL
OIL LEVEL
INTAKE VALVE CLOSED
EXHAUST VALVE CLOSED
CONNECTING ROD

(a) INTAKE OR SUCTION STROKE

INTAKE, OR SUCTION STROKE Descending piston develops partial vacuum. Fuel-and-air mixture is forced into the cylinder by atmospheric pressure from the carburetor and through the intake valve.

(b) COMPRESSION STROKE

COMPRESSION STROKE — Piston rises and compresses trapped fuel-air mixture.


INTAKE VALVE CLOSED
EXHAUST VALVE CLOSED
INTAKE VALVE CLOSED
EXHAUST VALVE OPEN
CAM
619

(c) POWER STROKE

POWER STROKE Spark plug fires and ignites fuel-air mixture. The burning gas expands and forces the piston down.

(d) EXHAUST STROKE

EXHAUST STROKE - Piston moves upward and forces burned gases from the cylinder through the exhaust open valve.

FIGURE 5. How a 4-stroke-cycle engine develops power.

- It causes a *partial vacuum* (*low pressure*) *in the cylinder*.
- The *intake valve opens* and allows a mixture of fuel and air to be forced into cylinder by atmospheric pressure. (The exhaust valve remains closed.)

- The intake valve is located in the cylinder block (Figure 5a) next to the carburetor. It is kept closed by a strong *spring* and is opened at the proper time by means of a *push rod* which is driven by a *cam*. The cam is located on a *camshaft* which is geared to the *crankshaft* or the cam may be on the crankshaft.

  A carburetor meters the gasoline and regulates the flow of air going into the cylinder through the intake valve. It is in the carburetor that air is mixed with the gasoline vapor.

STROKE 2 — **Compression** (Figure 5b) — As the piston completes its downward stroke and moves upward:

- *The intake valve closes and the exhaust valve remains closed.*

  The fuel-air mixture is compressed to approximately 1/6 of the volume it had at atmospheric pressure. The amount of pressure developed depends on the compression ratio of the engine (Figure 74).

  The compressing action increases the pressure of the fuel-air mixture to approximately 75 pounds per square inch.

STROKE 3 — **Power** (Figure 5c) — As the piston completes its upward stroke:

- *Both the intake and exhaust valves are closed.*
- *Compressed fuel and air are ignited.*

  An electric spark is developed at the spark plug, which ignites the fuel mixture.
- *The fuel-air mixture burns, and pressure inside the cylinder increases* because of the heat of combustion. Combustion temperatures average approximately 3600 degrees F.

  The pressure of the burning gases inside the cylinder increases to 3 or 4 times that of the compression pressure which is already 6 times normal atmospheric pressure. This pressure was developed during the compression stroke. The combined pressures drive the piston downward, or away from the cylinder head (Figure 5c).
- *The exhaust valve starts to open towards the end of the stroke.* The reason the exhaust valve opens toward the end of the power stroke is to allow for better scavenging — more complete removal of burned gases.

STROKE 4 — **Exhaust** (Figure 5d) — When the piston has completed the power stroke and starts upward:

- *The force of burning gases is gone.* The piston movement forces out remaining gases.

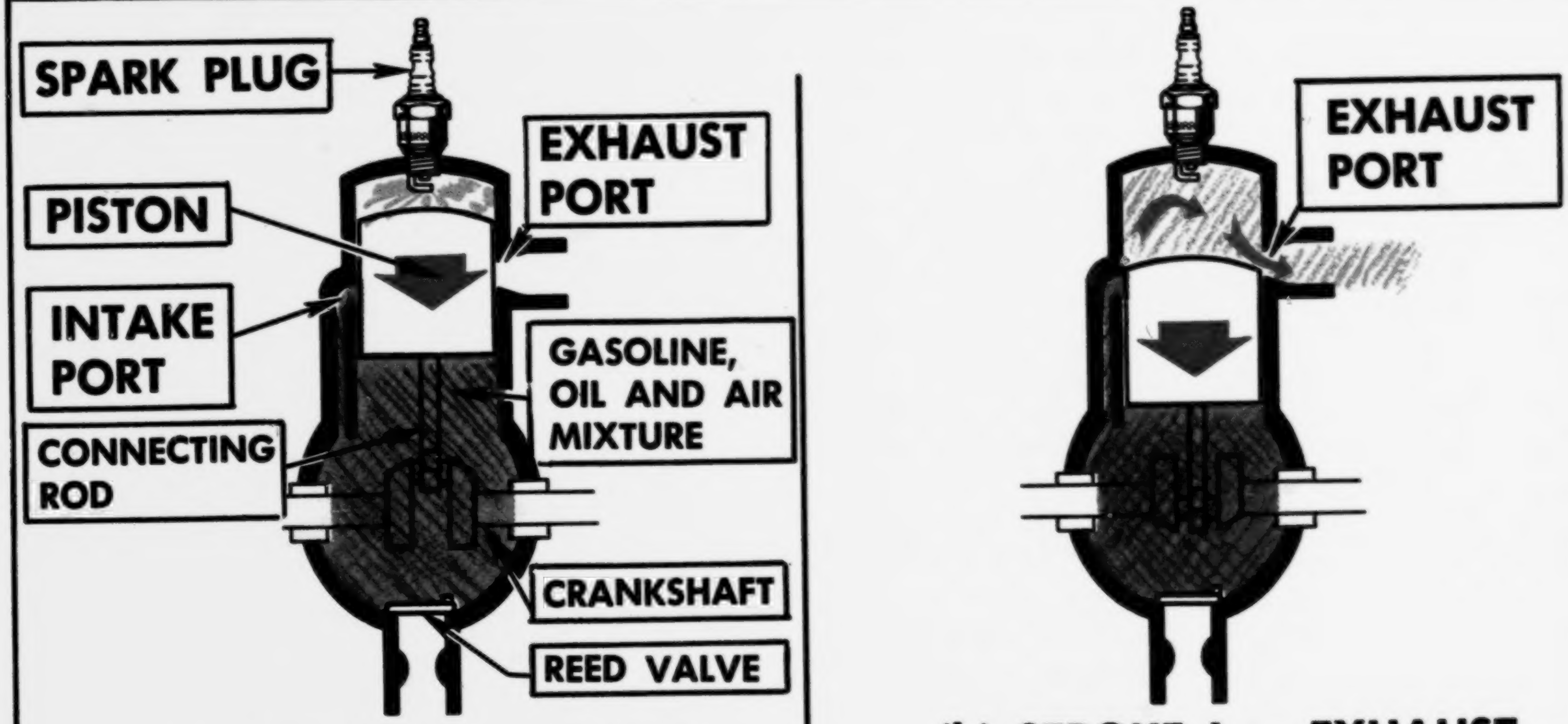
Here is how a **2-stroke-cycle engine** works. It is designed to complete all of the actions (a cycle) described for the 4-stroke-cycle engine, but it does them during one revolution of the crankshaft.

STROKE 1 — **Power-exhaust-intake** (Figures 6a, b, and c) — *As the piston moves downward,* away from the cylinder head, all three of the following events take place:

- **Power** (Figure 6a) — Pressure of the burning gases, caused by the heat of combustion, pushes the piston downward. This action provides power to turn the crankshaft through the connecting rod (Figure 6a). (The fuel was ignited about the time the piston reached the top of the previous stroke.)

  Before the piston reaches the end of its downward movement, it exposes in the cylinder two holes, or sets of holes, which are located on opposite sides *of the cylinder*. These holes are called "ports." One is the "exhaust port," and the other is the "intake port."
- **Exhaust** (Figure 6b) — The exhaust port is uncovered first. Hot gases, which are still under pressure from combustion, escape through the open exhaust port (Figure 6b).
- **Intake** (Figure 6c) — After the uncovering of the exhaust port, the intake port is uncovered. A fresh charge of the fuel-air mixture is forced into the combustion chamber. The charge comes from the crankcase where the fuel-air mixture is under pressure.

  Pressure develops in the crankcase as a result of the downward movement of the piston. The pressure causes the reed valve to close and pressure to build up in the crankcase.

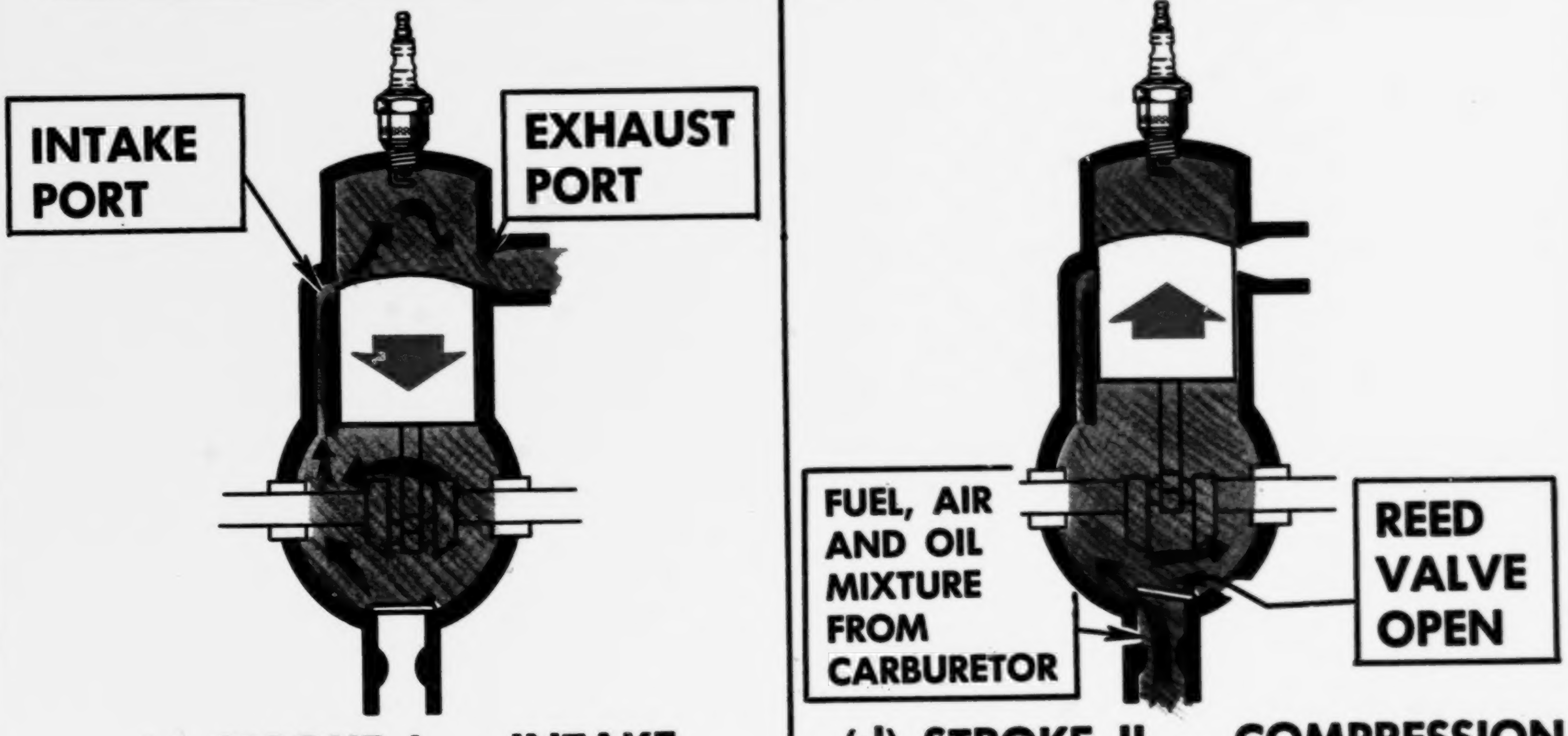

SPARK PLUG
PISTON
EXHAUST PORT
INTAKE PORT
GASOLINE, OIL AND AIR MIXTURE
CONNECTING ROD
CRANKSHAFT
REED VALVE
EXHAUST PORT

(a) STROKE I — POWER

Piston moves downward under pressure from expanding gases. Reed valve in crankcase closes. (Ignition occurred just before the downward stroke of the piston.)

(b) STROKE I — EXHAUST

Piston continues to move downward under pressure.
Exhaust port opens.


INTAKE PORT
EXHAUST PORT
FUEL, AIR AND OIL MIXTURE FROM CARBURETOR
REED VALVE OPEN

(c) STROKE I — INTAKE

Intake port opens. Fuel and oil mixture goes into cylinder.

(d) STROKE II — COMPRESSION

Piston moves upward, intake port closes. Exhaust port closes. Reed valve in crankcase opens. Fuel mixture is compressed in the cylinder.

620

FIGURE 6. How a 2-stroke-cycle engine develops power.

This is only a slight pressure compared to the compression pressure developed in the combustion chamber — approximately 4 to 6 pounds per square inch. It is enough, however, to force the new charge of fuel into the combustion chamber. This also helps to drive out the remaining exhaust gases.

STROKE 2 — **Compression** (Figure 6d) — *As the piston moves upward*:

- *Both ports are closed* (covered) by the piston so that the fuel-air charge in the cylinder is trapped and compressed.
- Just before the piston reaches the top of the upward stroke, a *spark* from the spark plug *ignites the mixture,* and it starts to burn. This begins another power stroke.
- Another event which does not occur in 4-cycle engines takes place in a 2-cycle engine during the compression stroke. *As the piston moves upward, a partial vacuum (low pressure) is created in the crankcase.* Atmospheric pressure opens the reed valve and forces a new charge of fuel and air (from the carburetor) into the crankcase.

Most valves in 2-cycle engines are of the metallic reed type.

Reeds are made of metal, phenolic or plastic. Some 2-cycle engines, however, have sliding valves, and others have rotary valves.

COMPARING 4-(STROKE) CYCLE AND 2-(STROKE)-CYCLE ENGINES*

To review briefly, the primary differences in the 4-cycle and the 2-cycle engines are as follows:

- The number of power strokes per crankshaft revolution (Figures 5 and 6).
- The method of getting the fuel-air mixture into the combustion chamber and the burned gases out.
- The method of lubricating the internal moving parts (Figure 7).

  Since the 2-cycle engine uses the crankcase for storing a reserve charge of fuel-oil-and-air mixture for the next stroke, the crankcase cannot be used exclusively as an oil compartment for lubricating the engine. Instead, lubrication is supplied by oil that is mixed with the fuel at the time the engine is refueled.

Because of these differences it is important that you know whether your engine is the 4-cycle or the 2-cycle type when you are servicing, operating, maintaining, or repairing it. When you are lubricating small engines:

- If you put a mixture of oil and gasoline in the oil sump of a 4-cycle engine, instead of crankcase oil, the engine will overheat because of lack of proper lubrication. The reasons for this are explained under "Lubricating Small Engines", page 57.
- If you put gasoline in a 2-cycle engine without first mixing it with oil, the engine will overheat because of lack of lubrication. It will not run very long before the piston and bearings will overheat, score, and seize. Two-cycle engines have a sealed crankcase but *no oil sump* (Figure 7b).

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*To simplify the term "stroke cycle," the word "stroke" will be omitted hereafter in this publication.

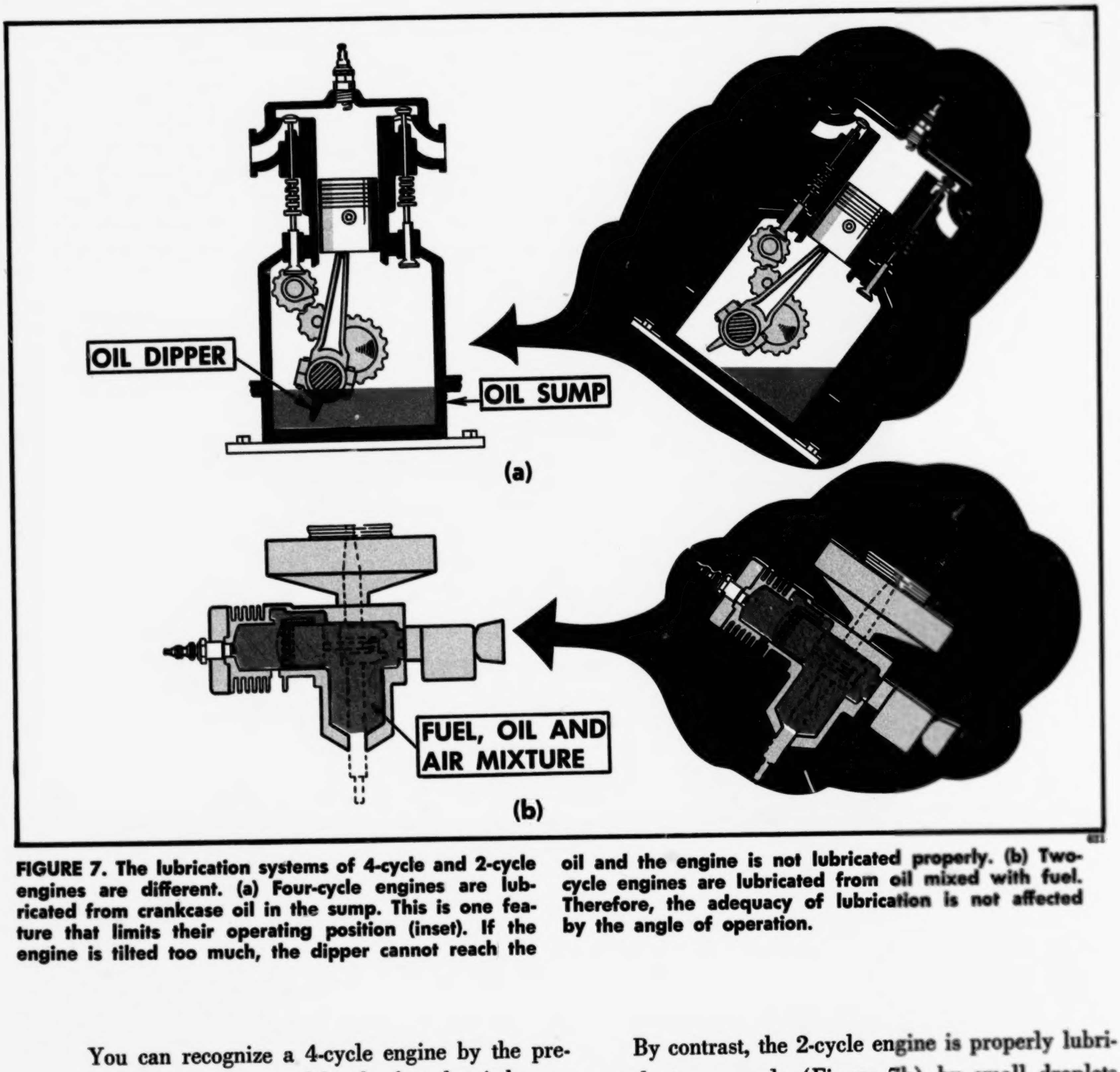


FIGURE 7. The lubrication systems of 4-cycle and 2-cycle engines are different. (a) Four-cycle engines are lubricated from crankcase oil in the sump. This is one feature that limits their operating position (inset). If the engine is tilted too much, the dipper cannot reach the oil and the engine is not lubricated properly. (b) Two-cycle engines are lubricated from oil mixed with fuel. Therefore, the adequacy of lubrication is not affected by the angle of operation.

You can recognize a 4-cycle engine by the presence of its **oil sump** and by the fact that it has an **oil-filler cap or plug** where oil can be added to the crankcase. These and other methods for identifying the type of engine are described under "Identifying Types of Small Engines," page 19.

Since a 4-cycle engine is dependent on an oil sump, the angle at which you operate it is critical. Figure 7a (inset) illustrates how the oil distribution is limited when the engine is tilted too much.

By contrast, the 2-cycle engine is properly lubricated at any angle (Figure 7b) by small droplets of oil suspended in the fuel-oil-and-air mixture in the crankcase.

This does not mean, however, that all 2-cycle engines can be operated at any angle. The type of carburetor is also a limiting factor. To learn why this is true, refer to "Types of Carburetors and How They Work," page 90.

IMPORTANCE OF PROPER CARE AND OPERATION

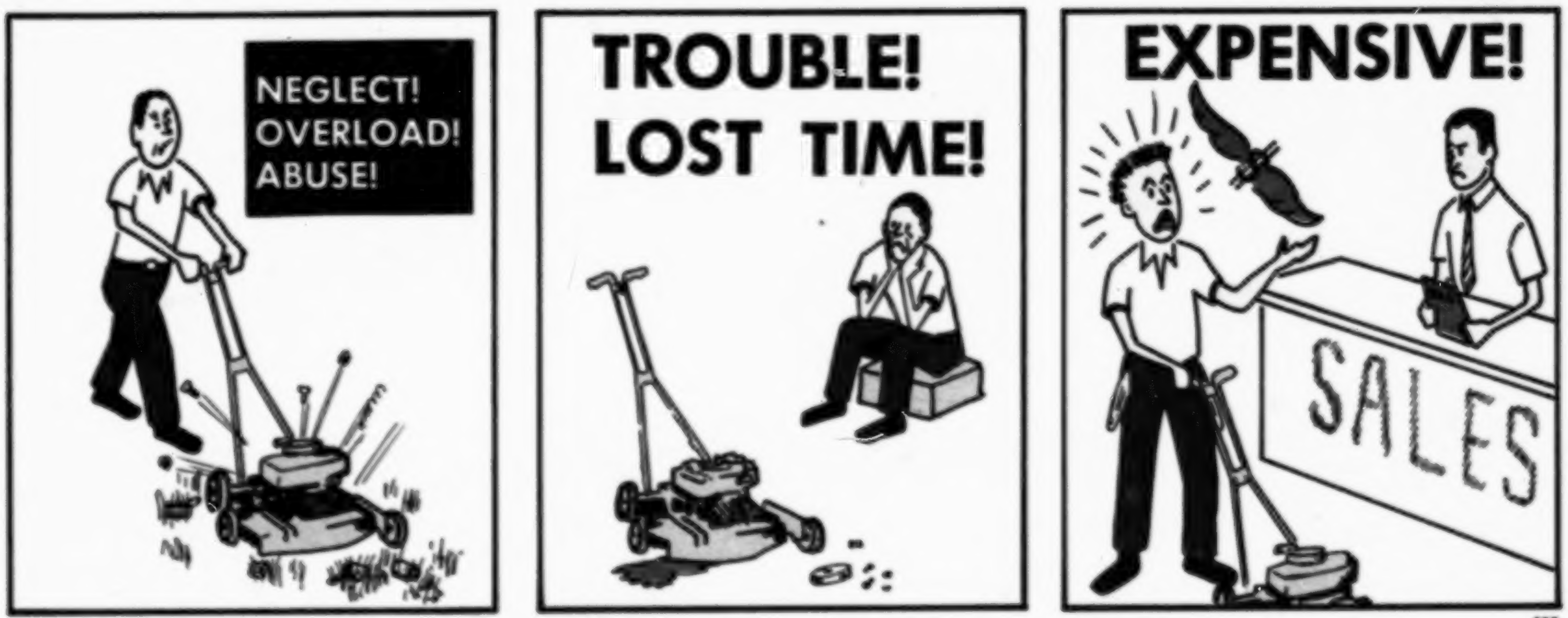

NEGLECT!
OVERLOAD!
ABUSE!
TROUBLE!
LOST TIME!
EXPENSIVE!
SALES
622

FIGURE 8. Neglect and abuse of small engines cause both annoyance and expense.

To make small engines "stand up" under the heavy demands to which they are subjected, manufactures provide them with *larger crankshafts, larger main bearings and larger oil supplies per horsepower* than those in automotive engines.

They are also built to meet a *government specification* which provides that the engine must be designed to operate under full load at top speed for 1,000 hours. Some have been known to run as long as 5,000 hours. A thousand hours, however, is usually considered a long life for small engines operated on an irregular basis. For example, if it takes you two hours to mow your lawn, and if you mow it every week for six months, that is only 48 hours per year. At such a rate, your mower engine should last 20 years. Occasionally, you hear of small engines lasting 20 years; but most of them give out much sooner than that.

If you are having operating troubles, high maintenance and repair cost (Figure 8), and your engine is short-lived, these problems are probably caused by the way you service and operate your engine. For example, you may permit the following to take place:

- **Allow dirt to enter the engine.**

  It is generally agreed among experts in the automotive industry that more than 50 per cent of early engine failures can be attributed to dirt.[2] This percentage is even higher with equipment such as lawn mowers and tillers. They operate with the engine near the ground, where a large amount of dust is usually present.

- **Fail to check the crankcase oil level regularly** (4-cycle engines).

  If the oil level is too low, the engine will not be lubricated properly.

- **Overload your engine.**
- **Run your engine too fast.**

  Some people change the governor setting on their engines in an attempt to develop more horsepower than that for which the engine was designed. If you increase the power output in this manner, you are asking for trouble.

One way to save yourself much trouble in servicing and operating your engine is to *save and use the operator's manual* that comes with your engine. It contains important information for your particular engine — information you must have when doing many of the servicing jobs.

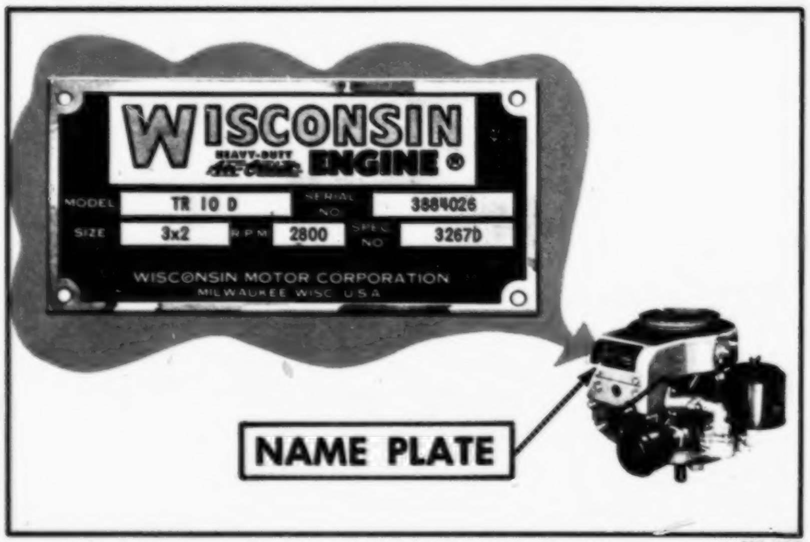


FIGURE 9. The engine nameplate gives important information for ordering new parts.

To get the proper parts for your engine, you must give the dealer the following information which is found on the nameplate or stamped on the cooling shroud (Figure 9). If you complete a form similar to the one in the Appendix, page 145, you will have the necessary information.

Information you may expect to find on the nameplate is as follows:

- **Make of engine,** or name of the manufacturer.
- **Model number or name of engine.** This number usually gives a clue as to the horsepower. Some model numbers refer to other information such as the type of crankcase and accessories. Some include information about certain modifications.
- **Serial number.** It tells the sequence in which the engine came off the assembly line. Modifications are made as production progresses. By knowing the serial number the manufacturer or dealer can tell which modifications have been made. Then the proper parts can be supplied.
- **Type number.** The type number identifies engines which require certain parts and accessories which are different from the parts originally designed for the engine.
- **Specification number.** This refers to different designs, requested by the equipment manufacturers, such as the length of power take-off end of the crankshaft.

The type and specifications information is included in the model and serial number on some engines. When recording the numbers, be careful not to confuse the engine number with the equipment number. They are very similar. Look for the engine number on the engine proper. Sometimes it is necessary on an old engine to rub the numbers with chalk to bring out the raised, or indented numbers.

One of the most common mistakes made by inexperienced persons is *failure to use the proper tools.* Never use pliers to loosen or tighten nuts or bolts. Use the proper size of wrench. The use of pliers will round the corners and make the nuts and bolts more difficult to remove. Using wrenches that are too big for the job or using extension handles may result in stripping threads. Keep your tools clean, orderly, and in good condition; and you will enjoy using them.

These points are so important to the welfare of a small engine that manufacturers will not guarantee your engine(s) if there is evidence that you are guilty of one or more of the violations listed.

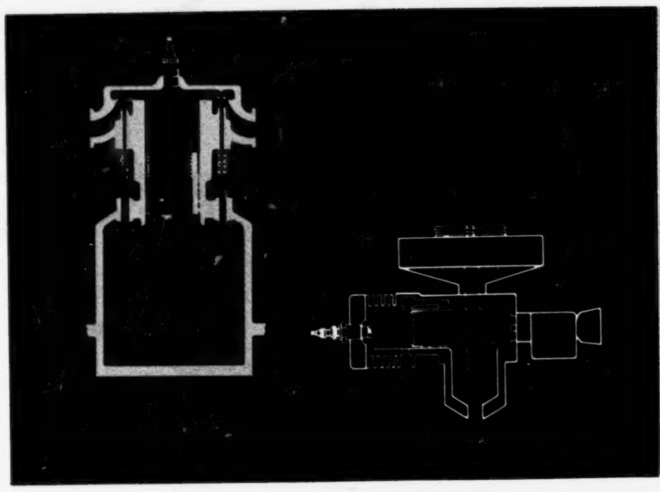
In addition to repair cost, you may find inconvenience and aggravation the most distasteful results of improper care and operation. For example, you may have had the perplexing experience of cranking a small engine for several minutes only to find that a simple adjustment, or a new spark plug, enabled it to start immediately.

How to avoid and how to correct problems in servicing and operating engines are explained under the following headings:

I. Servicing small engines.

II. Starting and operating engines.

III. Storing engines.



I.

SERVICING SMALL ENGINES

It is well recognized that if you expect to get trouble-free service from your engine, you must take time to service it regularly. When this should be done varies with the different manufacturers' recommendations, the operating conditions, and the type of servicing to be performed.

Manufacturers are in general agreement as to the minimum time interval for doing most jobs.

Before each operation you should (1) check the crankcase oil level in 4-cycle engines, and (2) fill the fuel tank with clean, fresh, regular gasoline. If yours is a 2-cycle engine, be sure the proper oil is thoroughly mixed with the gasoline.

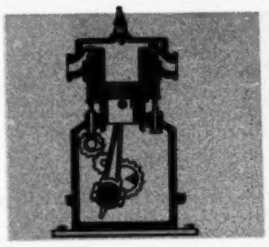
Two jobs should be done at least every **25 hours** of operation. They are (1) servicing carburetor air cleaners, and (2) changing the crankcase oil (4-cycle engines). If you are operating your engine in extremely dirty and dusty conditions, you should do these jobs more often.

As a rule, they recommend an **annual cleaning and general inspection.** At this time the fuel strainers and crankcase breather are cleaned and serviced.

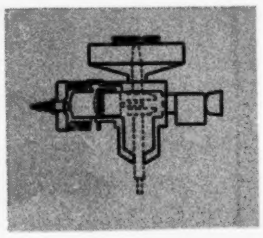
The following service jobs are discussed in the order you would do them from the start of an operating season. Of course most of them will need to be done repeatedly throughout the season.

The proper procedures for doing these and other service jobs are given under the following headings:

A. Identifying types of small engines.
B. Cleaning small engines.
C. Servicing carburetor air cleaners.
D. Servicing fuel strainers.
E. Servicing crankcase breathers (4-cycle engines).
F. Lubricating small engines.
G. Refueling small engines. (Fuel Selection-Use-Storage)
H. Servicing spark plugs.
I. Checking and adjusting carburetors.
J. Checking compression.
K. Checking and servicing batteries.

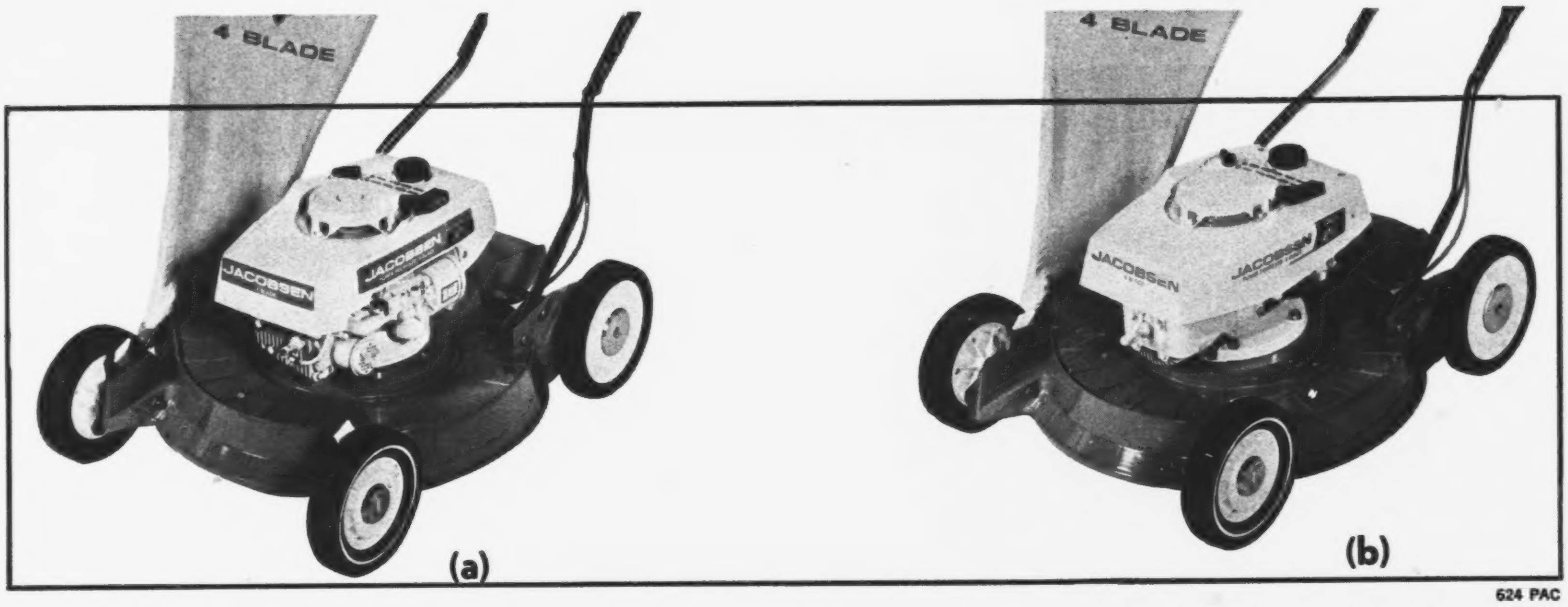


A. IDENTIFYING TYPES OF SMALL ENGINES



If you are not already familiar with the type of engine you plan to service, it is important that you determine which type it is before you start to service it. The reason is that the servicing procedures for some jobs on 4-cycle engines are not the same as for 2-cycle engines.

It is difficult to *recognize a 4-cycle from a 2-cycle engine* (Figure 10) unless you understand the principal differences. There are four methods you can use.


4 BLADE
JACOBSEN
(a)
4 BLADE
JACOBSEN
(b)

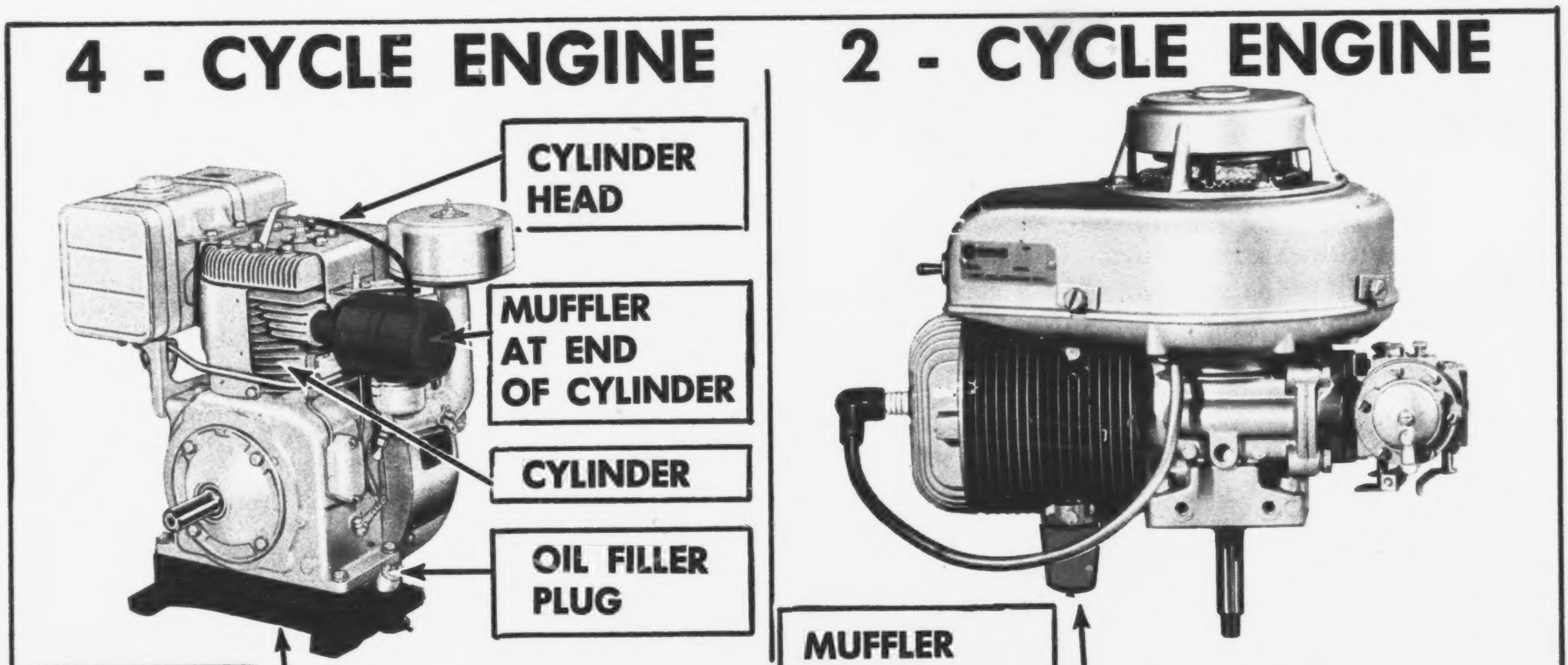
624 PAC

FIGURE 10. It is difficult to distinguish between a 4-cycle engine and a 2-cycle without close examination. (a) A lawn mower powered by a 4-cycle engine. (b) A lawn mower powered by a 2-cycle engine.

One method is to check for an oil **sump and oil filler plug or cap.** If yours has a sump and filler plug or cap, it is a *4-cycle engine* (Figure 11a). There is no oil sump on *2-cycle engines* (Figure 11b).

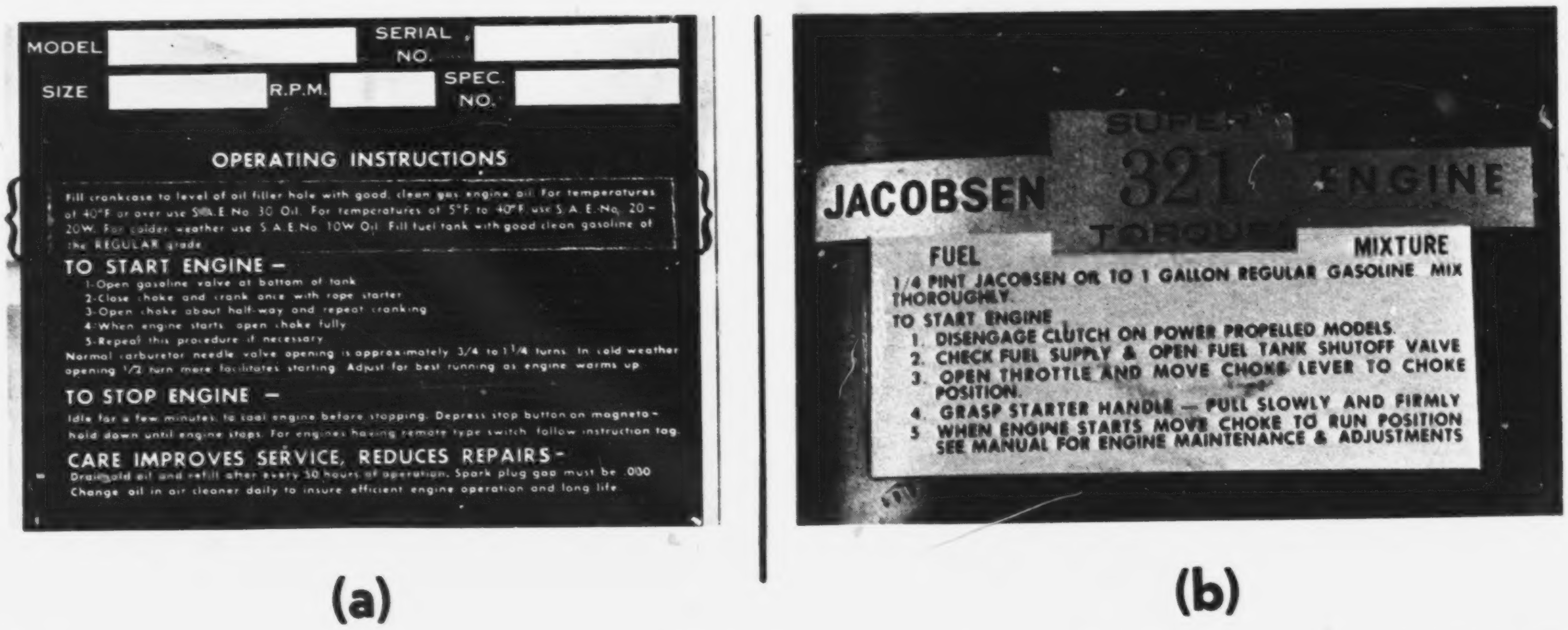
Another method is to check for the **location of the exhaust ports or muffler** (Figure 11). On a *4-cycle engine* the exhaust muffler connects at the cylinder-head end of the engine cylinder. The *2-cycle engine* has an exhaust port about midpoint on the cylinder.

A third method is to check the information on the **name plate** (Figure 12) or to check your **operator's instructions.** One, or both of them, should mention the oil specifications, or fuel-and-oil specifications. If either one gives the crankcase capa-


4 - CYCLE ENGINE
CYLINDER HEAD
MUFFLER AT END OF CYLINDER
CYLINDER
OIL FILLER PLUG
OIL SUMP
(a)
2 - CYCLE ENGINE
MUFFLER IN CENTER OF CYLINDER
(b)

(a) 625 B & S (b) 625 WB

FIGURE 11. Distinguishing features of the two types of engines. (a) A 4-cycle engine has an oil sump and oil filler plug or cap, and the exhaust muffler is located at the cylinder-head end of the cylinder. (b) A 2-cycle engine has no oil sump. The muffler, or exhaust port, is midway between the cylinder head and the crankcase.



MODEL
SERIAL NO.
SIZE
R.P.M.
SPEC. NO.

OPERATING INSTRUCTIONS

Fill crankcase to level of oil filler hole with good, clean gas engine oil. For temperatures of 40°F or over use S.A.E. No. 30 Oil. For temperatures of 5°F to 40°F use S.A.E. No. 20-20W. For colder weather use S.A.E. No. 10W Oil. Fill fuel tank with good clean gasoline of the REGULAR grade.

TO START ENGINE –

1-Open gasoline valve at bottom of tank
2-Close choke and crank once with rope starter
3-Open choke about half-way and repeat cranking
4-When engine starts, open choke fully
5-Repeat this procedure if necessary

Normal carburetor needle valve opening is approximately 3/4 to 1 1/4 turns. In cold weather opening 1/2 turn more facilitates starting. Adjust for best running as engine warms up.

TO STOP ENGINE –

Idle for a few minutes to cool engine before stopping. Depress stop button on magneto – hold down until engine stops. For engines having remote type switch, follow instruction tag.

CARE IMPROVES SERVICE, REDUCES REPAIRS –

Drain old oil and refill after every 50 hours of operation. Spark plug gap must be .030
Change oil in air cleaner daily to insure efficient engine operation and long life.

(a)

JACOBSEN SUPER 321 TORQUE ENGINE

FUEL MIXTURE

1/4 PINT JACOBSEN OIL TO 1 GALLON REGULAR GASOLINE. MIX THOROUGHLY.

TO START ENGINE
1. DISENGAGE CLUTCH ON POWER PROPELLED MODELS.
2. CHECK FUEL SUPPLY & OPEN FUEL TANK SHUTOFF VALVE
3. OPEN THROTTLE AND MOVE CHOKE LEVER TO CHOKE POSITION.
4. GRASP STARTER HANDLE — PULL SLOWLY AND FIRMLY
5 WHEN ENGINE STARTS MOVE CHOKE TO RUN POSITION
SEE MANUAL FOR ENGINE MAINTENANCE & ADJUSTMENTS

(b)

(a) 626 WIS (b) 626 JAC

FIGURE 12. Information on the name plate will usually give you a clue as to whether yours is a 4-cycle or a 2-cycle engine. (a) A typical name plate from a 4-cycle engine giving oil recommendations for the crankcase. (b) A typical name plate from a 2-cycle engine giving specifications for mixing oil and gasoline.

city or a kind of crankcase oil, this applies only to *4-cycle engines.* If mixing oil and gasoline is mentioned, this would identify it as a *2-cycle engine.*

If none of these methods are adequate and you are still uncertain about the identification of your engine, use the **compression method.** Proceed as follows:

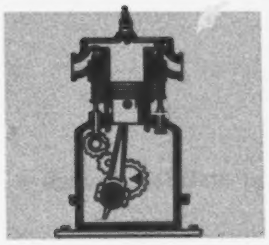
1. *Disconnect the spark plug to prevent the engine from starting.*

   Make sure the connector is not touching the spark-plug terminal.

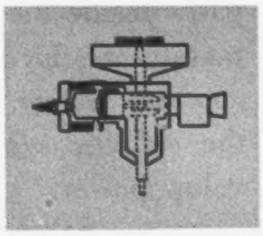
2. *Put a chalk mark on the starter flange or pulley.*
3. *Crank the engine slowly by hand.*

   If resistance — caused by compression — is felt at only every other revolution, it is a *4-cycle engine.*

   If the resistence — caused by compression — is felt at each revolution, it is a *2-cycle engine.*



B. CLEANING SMALL ENGINES



The term "cleaning the engine" in this discussion refers to cleaning the outside of the *crankcase and accessories, the cooling system, and the exhaust system.*

The importance of keeping your small engine clean and how to clean and inspect it are discussed under the following headings:

1. How small engines are cooled.
2. Importance of cleaning the engine.
3. Tools and materials needed.
4. Cleaning and inspecting the crankcase and accessories.
5. Cleaning and inspecting the cooling system.

HOW SMALL ENGINES ARE COOLED

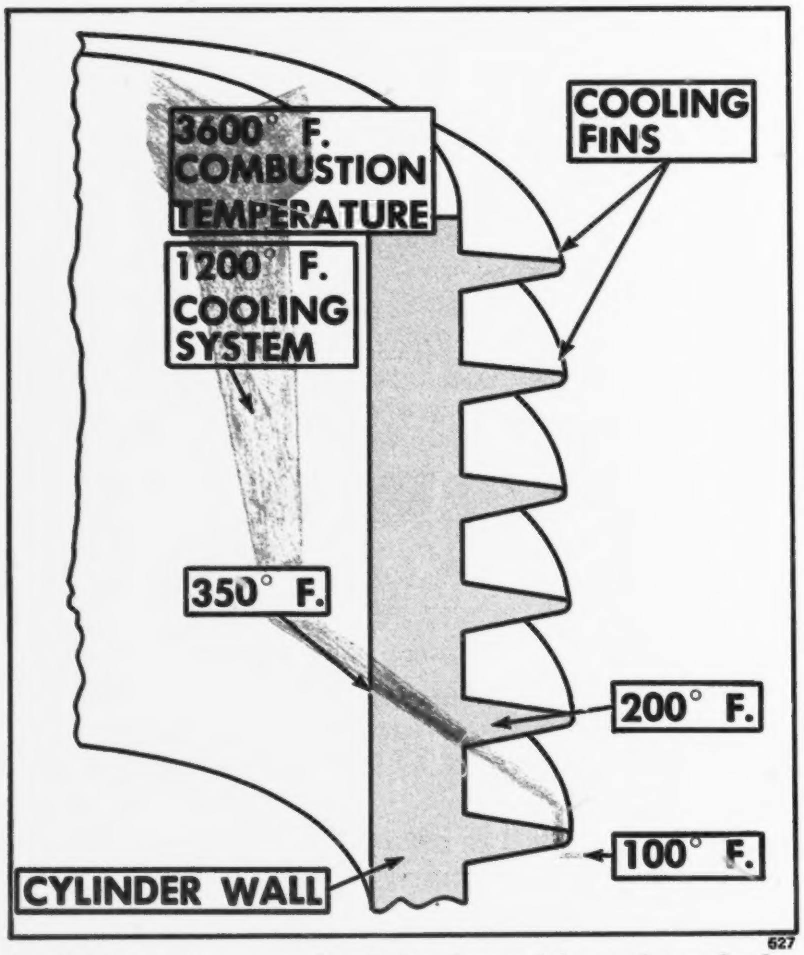


FIGURE 13. As a result of the loss of heat through the cylinder walls, to the cooling system, the temperature is reduced from 1200 degrees F. to approximately 350 degrees F. at the inside of the cylinder wall, and to 100 degrees F. at the outer edge of the cooling fins.

To appreciate the importance of keeping the cooling system clean, you need to understand the cooling principles of all air-cooled engines. As shown in Figure 13, the average temperature of burned gases inside the cylinder is about 3600°F. Approximately one-third of the heat is given off through the *cooling system.* Another one-third is lost through the *exhaust system.* The remainder is used to develop power.

In Figure 13 note that the temperature along the inner cylinder wall averages 350°F. as contrasted to the burning gas temperature in the cylinder of 3600°F. The reason for the cooler temperature along the cylinder wall is a "boundary" layer of gas which has been found to lie next to it. This is a rather stagnant layer which acts as an insulating film. For this reason there is not so much heat moving through the cylinder walls as you might imagine, especially when contrasted to the intense heat developed from the burning fuel inside the cylinder.

The temperature decreases to about 200°F. as the heat moves through the cylinder wall to the outer surface. This heat is given off rapidly with forced air movement over the outer wall and the cooling fins.

Heat travels through the cooling system in the following way. The heat moves from the cylinder through the cylinder walls by "conduction."* When it reaches the outer surfaces of the cylinder, it is taken up by the air through "forced convection."** Forced convection is accomplished by a flywheel blower forcing air past the cylinder wall and the cooling fins. It is directed around the cylinder by the cylinder baffles (Figure 14a). This is why you should never operate an engine with the baffles removed.

The cooling fins are used to provide increased surface around the outside of the cylinder for additional cooling area. This is necessary on air-cooled engines and not on water-cooled engines because air is approximately one twenty-fifth as effective as water when used for cooling engines.

**Conduction* is the term used to describe heat transfer through a solid conductor.

***Convection* is the term used to describe heat transfer through movement of a gas - in this case air. When air is heated, it becomes less dense and rises. Cool air moves in to replace it. This is natural convection. Forced convection is accomplished by using a fan to help speed the convection action. In this way the hot air on the cooling fins is replaced faster by cooler air being forced past them by the flywheel blower.

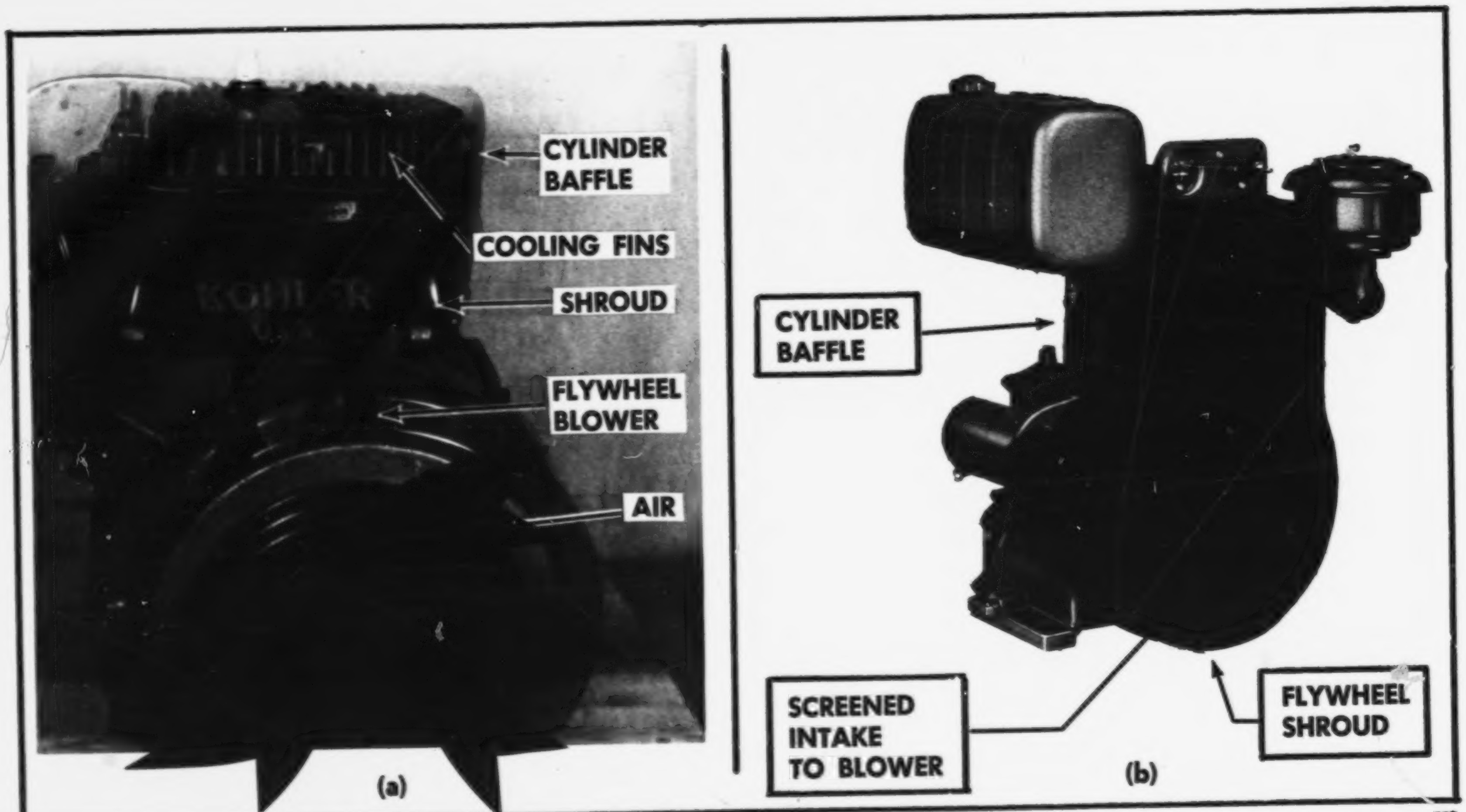

CYLINDER BAFFLE
COOLING FINS
SHROUD
FLYWHEEL BLOWER
AIR
(a)
CYLINDER BAFFLE
SCREENED INTAKE TO BLOWER
FLYWHEEL SHROUD
(b)
628

FIGURE 14. How an air cooled engine is cooled. (a) Air from the blower is directed over the engine by a shroud and baffles. The shroud may also be called a "cylinder air duct," or a "blower housing." As the air passes the fins on the engine head, it absorbs heat which is discharged back to the atmosphere. (b) The intake area is screened to prevent large particles of dirt and trash from entering. Small particles, however, enter and collect on the fins and throughout the cooling system. This slows the flow of air and decreases its effectiveness for taking up heat unless the accumulation is removed regularly.

IMPORTANCE OF CLEANING THE ENGINE

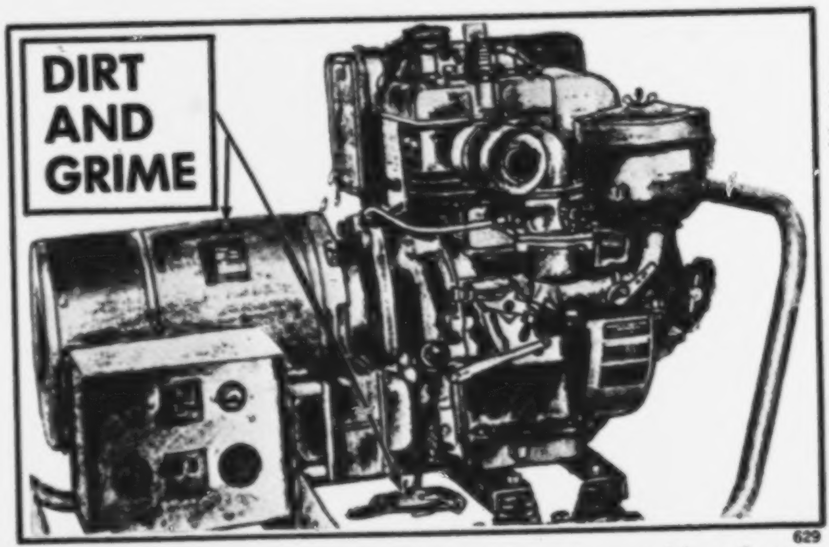

DIRT AND GRIME
629

FIGURE 15. Accumulations of dirt on the outside of an engine interfere with cooling; dirt gets into the engine and causes wear.

If you fail to clean your engine regularly (Figure 15), its efficiency is reduced along with its time of useful service. For example, the following may happen:

- The engine overheats.
- Dirt gets inside the engine.
- Rubber parts soften and break down.
- Loose nuts and cracks are covered and go unnoticed until major damage is done.
- Neglect becomes a habit.

Overheating can be caused by *dirt and grime on the outside of the engine* and by a *clogged or restricted exhaust system.*

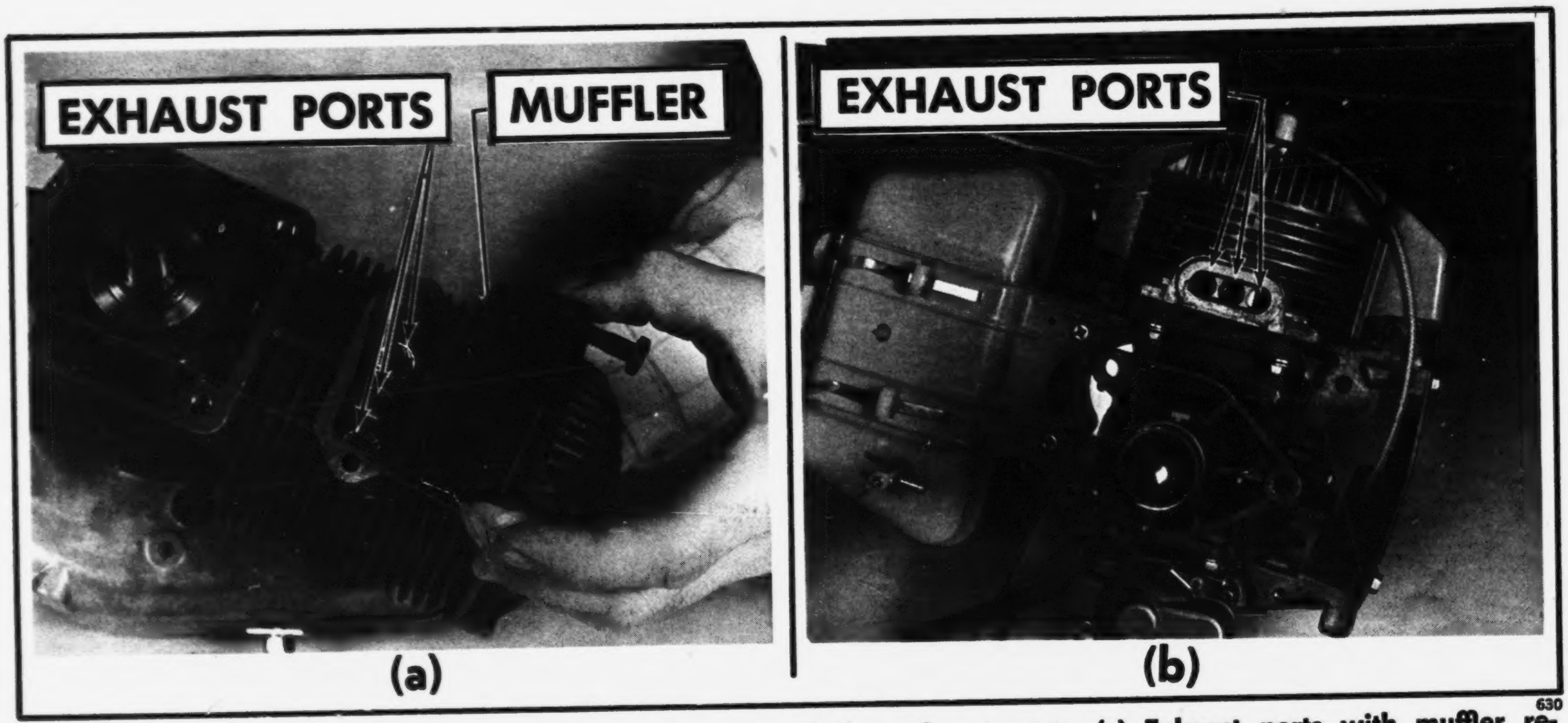


FIGURE 16. Two-cycle engines accumulate carbon around the exhaust ports. (a) Exhaust ports with muffler removed. (b) Exhaust ports with no provision for a muffler.

When dirt and grime collect on the fins, they tend to insulate the fin area so that heat does not move readily into the air stream. The engine temperature increases excessively during operation. The collection of deposits can reach the point at which the space between the fins may be completely blocked and the engine overheats.

A *clogged muffler will also cause an engine to overheat.* It creates a back pressure in the cylinder and prevents the hot gases from escaping readily. (Remember that one-third of the combustion heat is given off through the exhaust system.)

Overheating in turn, causes *valve-guide distortions, cylinder warping, scuffing and scoring of cylinder walls, sticking valves, loss of power,* and eventually *engine failure.*

Another reason for keeping your engine clean is to **prevent dirt from getting inside the engine.** Much of the dirt that enters the engine comes from deposits on the outside. Dirt particles which enter the lubrication area of an engine *cause rapid wear on bearings* and other surfaces which slide against one another. Once dirt mixes with oil, a harmful grinding mixture is developed.

Unless you are extremely careful, dirt will enter the engine when you check the crankcase oil level or refuel the engine.

Dirt may also get into the air cleaner assembly when the filter is removed. This restricts air flow into the carburetor; then some of the dirt will enter the cylinder during engine operation.

With 2-cycle engines dirt and other foreign materials may enter the exhaust ports and lodge on the cylinder walls.

Oil or gasoline which collects on rubber parts, such as the spark plug wire, V-belt, and rubber hoses, *causes them to soften and deteriorate rapidly.*

Another advantage of cleaning an engine is to reveal any parts that might have become defective, loose, or broken. These parts can be repaired before extensive damage is done.

Most engines are sold with a *warranty.* The warranty provides for the replacement of defective parts for a period varying from approximately 45 days to as long as one year after the date of purchase. If your engine is new and you can discover defects during that period of time, you will save the cost of putting the engine back into top operating condition.

Once you get behind on servicing your engine and it becomes dirty and rusty, you lose your *sense of pride* in owning the engine and have a tendency to neglect and abuse it. You are more likely to overload the engine, operate it too fast, and neglect to service it properly.

Consequently, it is important that you set aside a definite time each year — at the start of the season or at regular intervals during the season — for completely cleaning the outside of the engine and the cooling system. You should also clean the engine before it is to be serviced or repaired.

TOOLS AND MATERIALS NEEDED

1. Slot-head screwdrivers — 4″ and 6″
   Phillips-head screwdrivers — 4″ and 6″
2. Socket set — including 3/8″, 7/16″, 1/2″, 5/8″, and 9/16″ sockets and 3/8″ ratchet handle
3. Open-end wrenches of the same sizes as indicated for socket wrenches
4. Nut drivers — ¼″, ⅜″
5. Wire brush
6. Pail — approximately 10-qt. capacity
7. Paint brush
8. Water hose equipped with nozzle
9. Small wooden scraper and/or a small putty knife
10. Old toothbrush, if available
11. Commercial degreaser (Petisol 404, Gunk, or equivalent); or petroleum solvent (mineral spirits, kerosene, or diesel fuel); or steam cleaning equipment
12. Hand sprayer

A *fire extinguisher* is also desirable in case of fire. It should be of the dry-chemical, carbon-dioxide, or foam type to be effective for gasoline or other petroleum-type fires.

If an *air compressor* that can be set for a pressure of approximately 100 pounds (per square inch) is available, it is very helpful in removing dirt from hard-to-reach places.

CLEANING AND INSPECTING THE CRANKCASE AND ACCESSORIES

You may use any one of three different solutions for cleaning an engine. They are (1) a commercial solvent usually called a "de-greaser", (2) common petroleum solvent such as mineral spirits, kerosene, or diesel fuel; or (3) live steam.

The **de-greaser** is somewhat faster than the other solvents. Furthermore, it does a better job of cleaning the hard-to-reach places. Neither the common petroleum solvents nor steam is satisfactory for removing mud and other substances that do not contain oil or grease.

CAUTION! Do not use gasoline for cleaning your engine. It is highly flammable and an extreme fire hazard.

De-greasers are available in small spray cans (Figure 17a), or you can buy a more concentrated form (Figure 17b). The concentrated de-greaser is much less expensive, since you can dilute it with three to ten parts of mineral spirits, kerosene, or diesel fuel. At this rate a quart of the concentrate is enough to clean your engine several times. If your engine is exceptionally dirty, use a more concentrated solution.

CAUTION! If you use a de-greaser, check the instructions on the can. Some are flammable and dangerous if used in a closed building or near a flame.

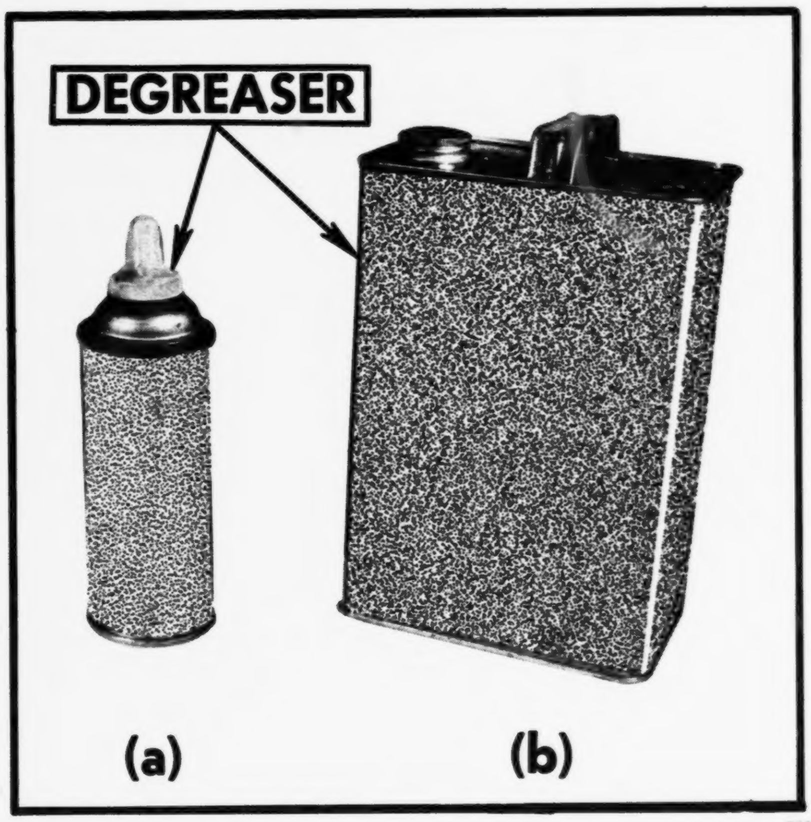


FIGURE 17. De-greasers are available (a) in small pressure-type cans, or (b) in bulk as a concentrate requiring dilution before being applied.

Procedures for cleaning your engine are as follows:

1. *Allow the engine to cool, if it has been running.*

   A hot engine will evaporate the cleaning solvent before it has had time to become effective. If water is present, the vapor may condense on the breaker points and prevent the engine from starting. But if the engine is warm, not hot, the dirt and grease are more easily dissolved.

2. *Remove the blower shroud and cylinder baffles.*

   Refer to the steps under the next heading for procedures.

3. *Inspect for oil leaks and fuel leaks.*

   Where there is an **oil leak,** there is often an excessive accumulation of dirt which enables you to locate the leak more readily than after the engine is cleaned.

   Where there is a **fuel leak,** the area may be clean, with the exception of reddish deposits left from the evaporation of the fuel, and a tendency for the paint to blister.

4. *Remove air-cleaner and cover air-cleaner opening.*

   It is best to remove the air cleaner and to cover the carburetor intake with a piece of plastic sheeting. Use a rubber band to hold the plastic sheet in place. It prevents the cleaning solution from entering the carburetor. Instructions for removing the air-cleaner are given under "Servicing Carburetor Air Cleaners," page 32.

5. *Clean the exhaust system* (Figure 18).

   a. **If you have a 4-cycle engine,** you will not likely have trouble with the muffler clogging. Proceed to step 6.

   b. **If your engine is the 2-cycle type,** it is important that you clean the exhaust ports. Proceed as follows:

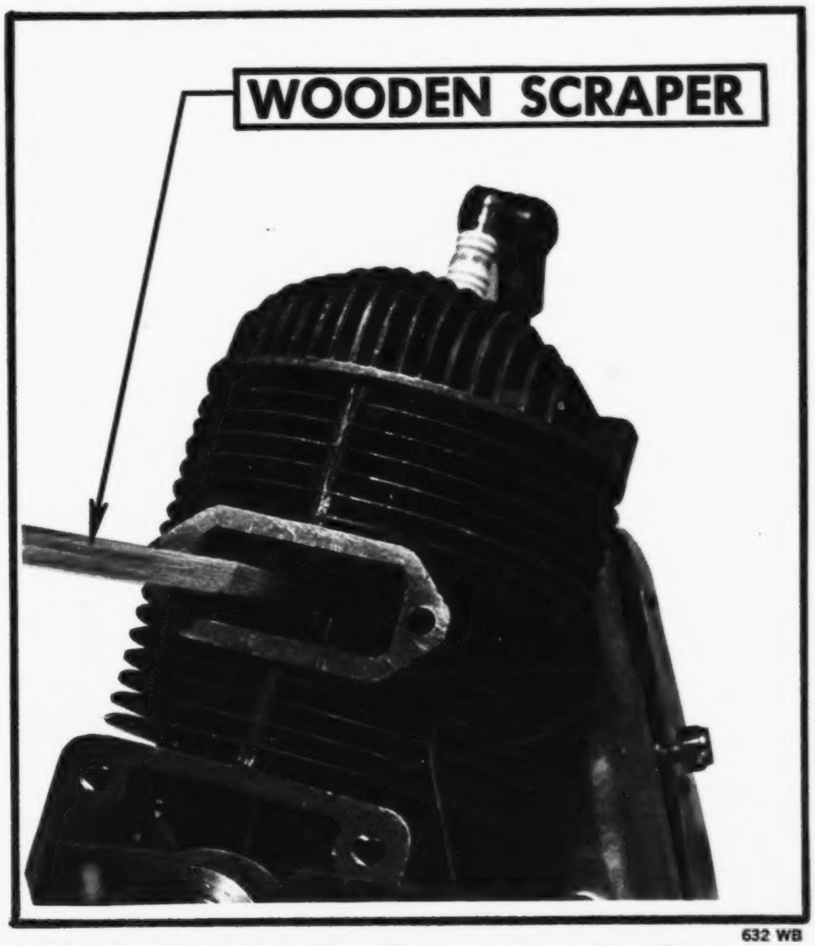


FIGURE 18. Cleaning the exhaust ports on 2-cycle engines with a wooden scraper.

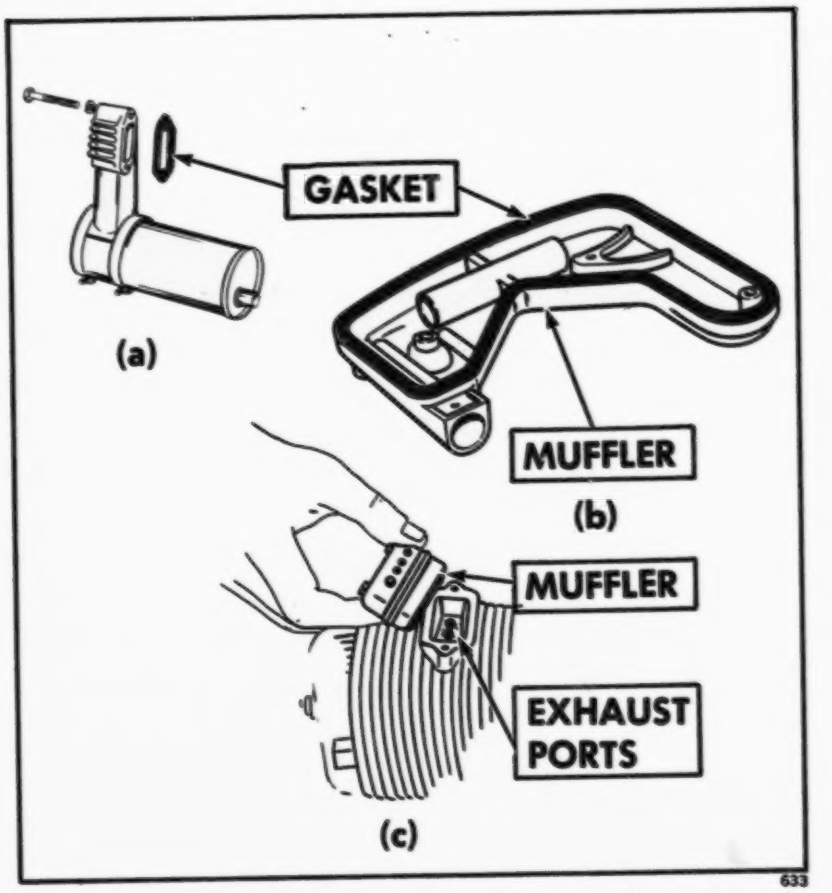


FIGURE 19. Three types of mufflers used on 2-cycle engines. (a) a cylindrical muffler, (b) a box-like muffler, and (c) a cone shaped muffler.

(1) *Remove the muffler, if one is on your engine (Figure 19).*

(2) *Check cylinder exhaust ports for carbonizing (Figure 16).*

(3) *Rotate crankshaft until the piston covers the exhaust ports.*

This avoids the possibility of scraping carbon and dirt into the piston rings and causing increased wear.

(4) *Clean exhaust ports (Figure 18).*

Use a wooden scraper so as not to damage the chamfered edges.
Scrape so that carbon will not enter cylinder.

(5) *Clean the muffler in solvent.*

(6) *Replace the muffler before cleaning the engine (Figure 19).*

This is to prevent the cleaning solvent from getting into the cylinder. It can cause corrosion and interfere with lubrication.

If your engine has no muffler, cover the exhaust port(s).

Install a new gasket when installing the muffler. A leaking gasket will cause noisy operation.

Mufflers vary in shape and size, but they are usually attached to the cylinder by two capscrews and a gasket.

6. *Apply solvent on areas that need cleaning.*

   If you are using a **de-greaser** (unless it is in a pressure-type can), apply it with a paint brush, or hand sprayer (Figure 20) in order to get a thin, well-distributed film. Apply liberally until the surface has a moist appearance.

   If you are using a petroleum **solvent without a de-greaser,** apply it with a paint brush to help get better penetration.

7. *Let the solvent set approximately 5 minutes whether you use a de-greaser, petroleum solvent or a mixture of the two.*

   This gives the solution time to do an effective job of penetrating and loosening the grease and oil particles.

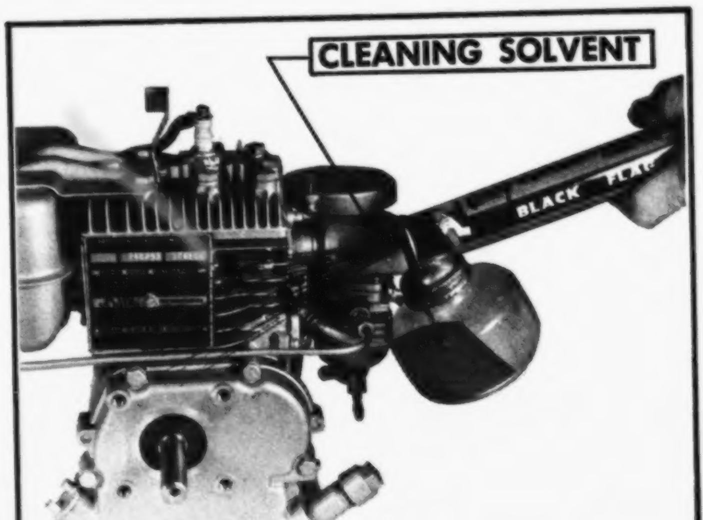


FIGURE 20. De-greaser or petroleum solvent applied with a hand sprayer.

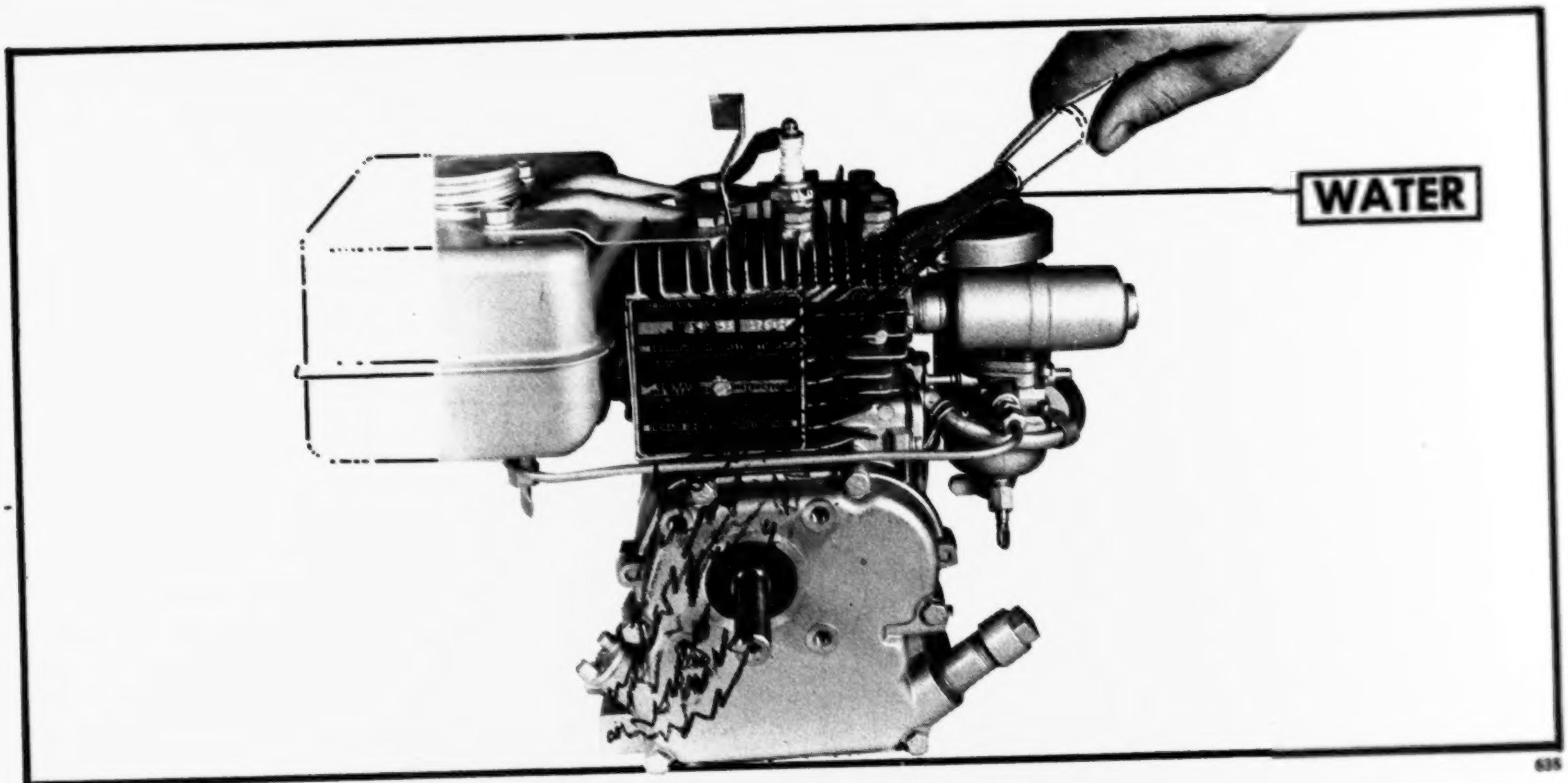


FIGURE 21. Cleaning solutions are removed with a strong water spray.

8. *Remove solvent from the engine surface.*

   If you used a **de-greaser,** apply a strong stream of water (Figure 21). Continue to flush until all milky substance is removed from engine.

   If you used a **petroleum solvent,** remove it with a strong soap solution. Apply the soap solution with a paint brush; then flush it off with water.

   Apply spray sparingly in the area of the breaker points, to avoid possible shorting of the ignition circuit.

9. *Check for areas that have been missed.*

   Use a scraper and a wire or bristle brush to remove accumulations that did not flush off. Reapply de-greaser if needed to remove remaining accumulations of grime.

   If you have cleaned the engine thoroughly by this method, proceed to step 10. If the cooling system is still dirty, proceed to "Cleaning and Inspecting the Cooling System," page 28.

10. *Remove protective covers.*

11. *Replace the carburetor air cleaner.*

    The air cleaner should be serviced before installation. See procedures under "Servicing Carburetor Air Cleaners" page 32.

12. *Operate the engine immediately for three to five minutes.*

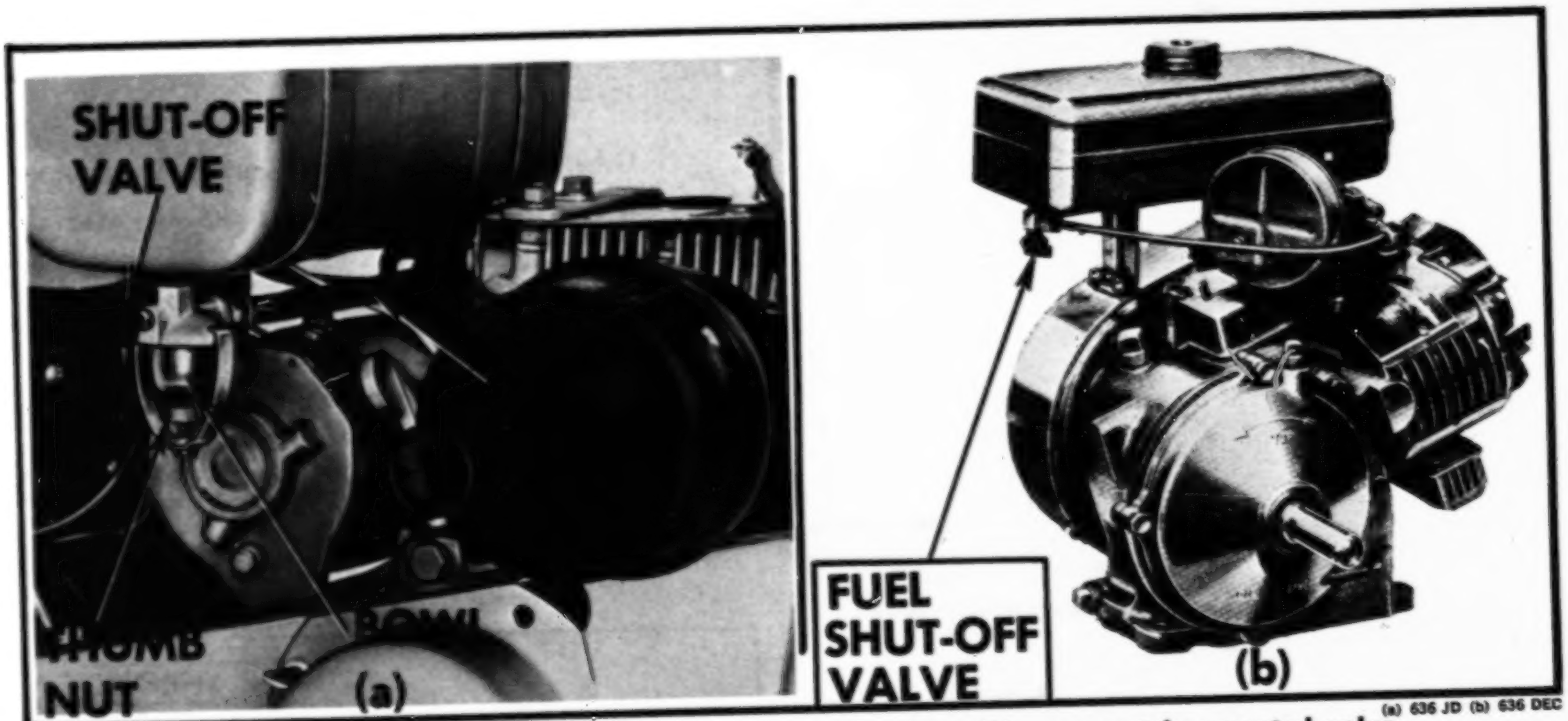
    Heat from the engine operation will help it to dry and help to remove water from vital parts.

CLEANING AND INSPECTING THE COOLING SYSTEM

1. *Close the fuel shut-off valve.*

   Not all engines have shut-off valves. If yours has one, it may be either a part of the sediment bowl (Figure 22a) or a single unit (Figure 22b).

   If your engine has no shut-off valve, disconnect the supply tube to drain the tank.

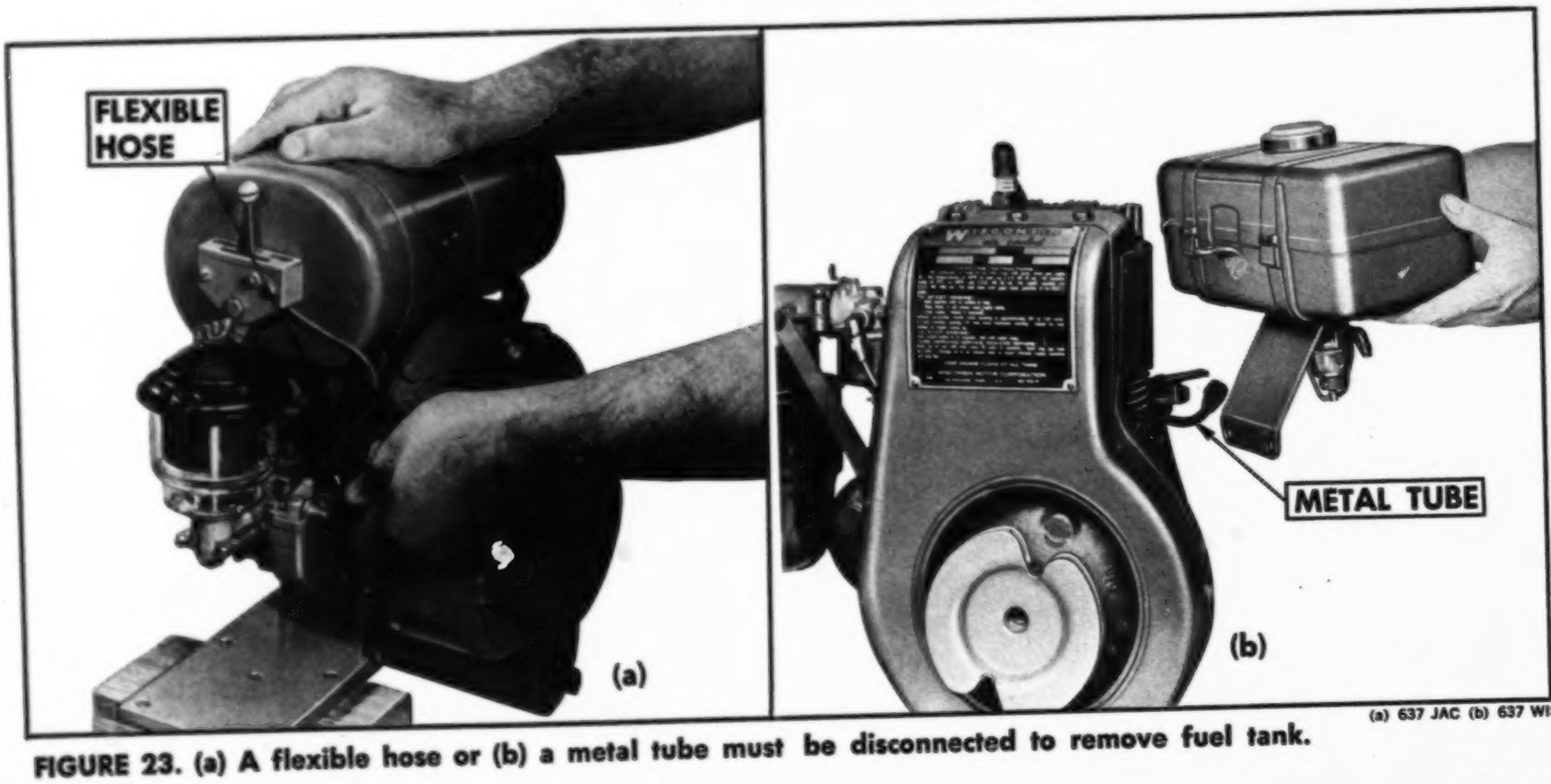

SHUT-OFF VALVE
THUMB NUT
BOWL
(a)
FUEL SHUT-OFF VALVE
(b)

(a) 636 JD (b) 636 DEC

FIGURE 22. A shut-off valve may be (a) a part of the sediment bowl, or (b) a separately mounted valve.

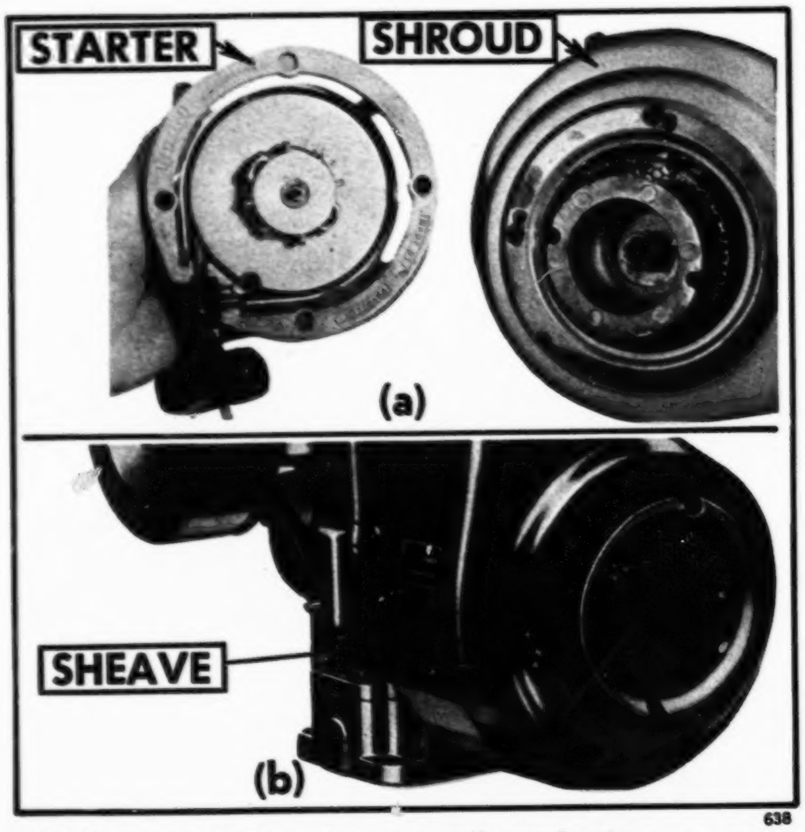
2. *Remove fuel tank if necessary for removing the flywheel shroud.*

This will require disconnecting a flexible hose (Figure 23a) or a metal tube (Figure 23b). Be sure to cover the end of the fuel lines so dirt and cleaner will not enter while you are cleaning the engine. Use a piece of plastic sheeting to cover the opening and a rubber band to hold it in place.


FLEXIBLE HOSE
(a)
METAL TUBE
(b)

(a) 637 JAC (b) 637 WIS

FIGURE 23. (a) A flexible hose or (b) a metal tube must be disconnected to remove fuel tank.



638

FIGURE 24. (a) The starter recoil mechanism on some engines is removed before removing the shroud. (b) A removable screened sheave.

3. *Remove the recoil starter (Figure 24) or screened sheave if equipped with a self-starter.*

   Some engines with a rope-wind starter, or a self-starter, have a screen mounted in the sheave opening. See "Maintaining and Repairing Starters," Volume II.

   If your engine has a rope-rewind starter, the screen is mounted separately (Figure 24).

4. *Remove the blower shroud (Figure 25).*

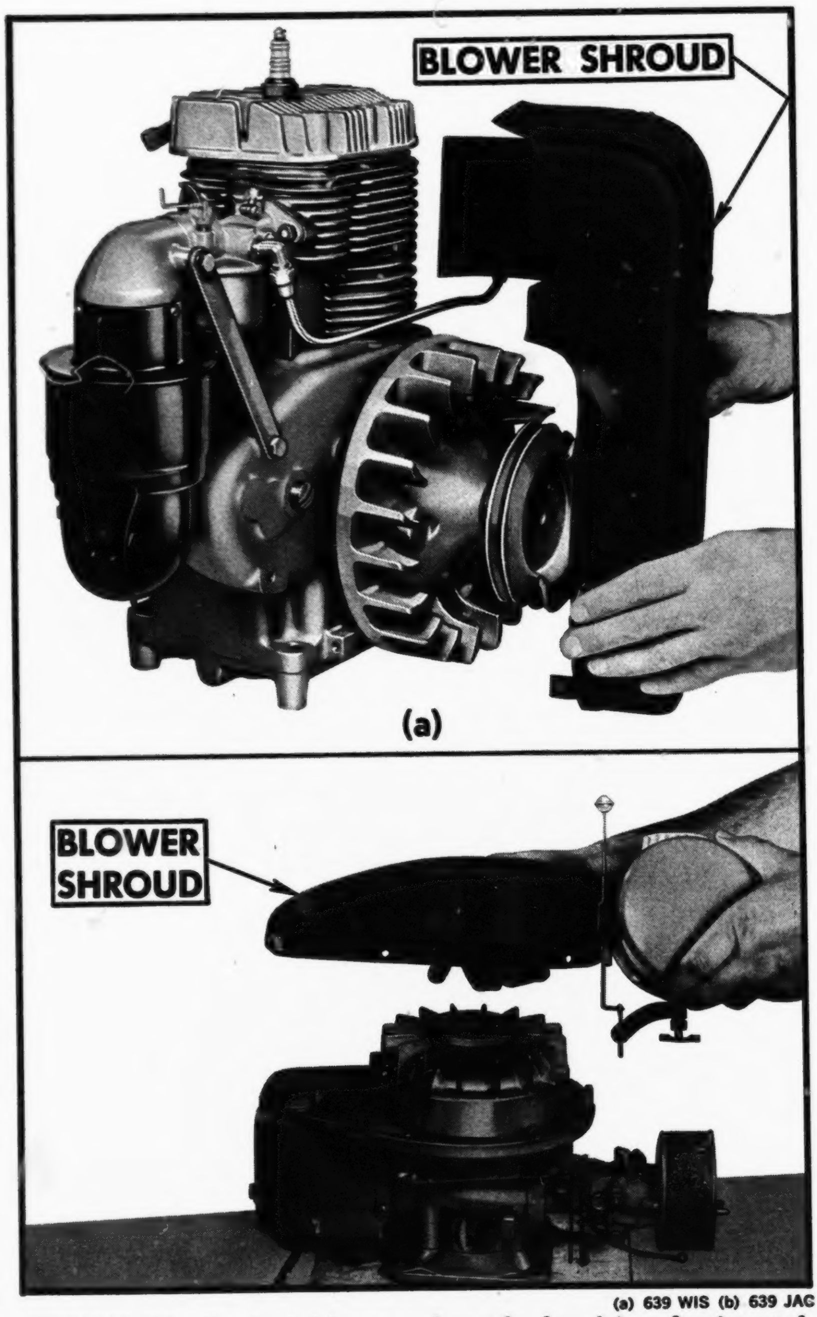
   There are a few engines which require removal of some of the accessories such as the air cleaner, muffler, governor spring, or spark-plug wire before removing the blower shroud.

5. *Remove remaining baffles and deflectors that divert air from shroud around and over end area of cylinder (Figure 26).*

Some engines have additional baffles welded to the blower shroud.

Others use one or more separately mounted baffles as needed to direct the air over the finned area.

WARNING! Do not operate your engine with the shroud and baffles removed. It will overheat. Those equipped with a governor which is sensitive to air flow through the cooling system, will provide no speed control. The engine will overspeed.



(a) 639 WIS (b) 639 JAC

FIGURE 25. Typical blower shrouds for (a) a horizontal-crankshaft engine and (b) for a vertical-crankshaft engine.

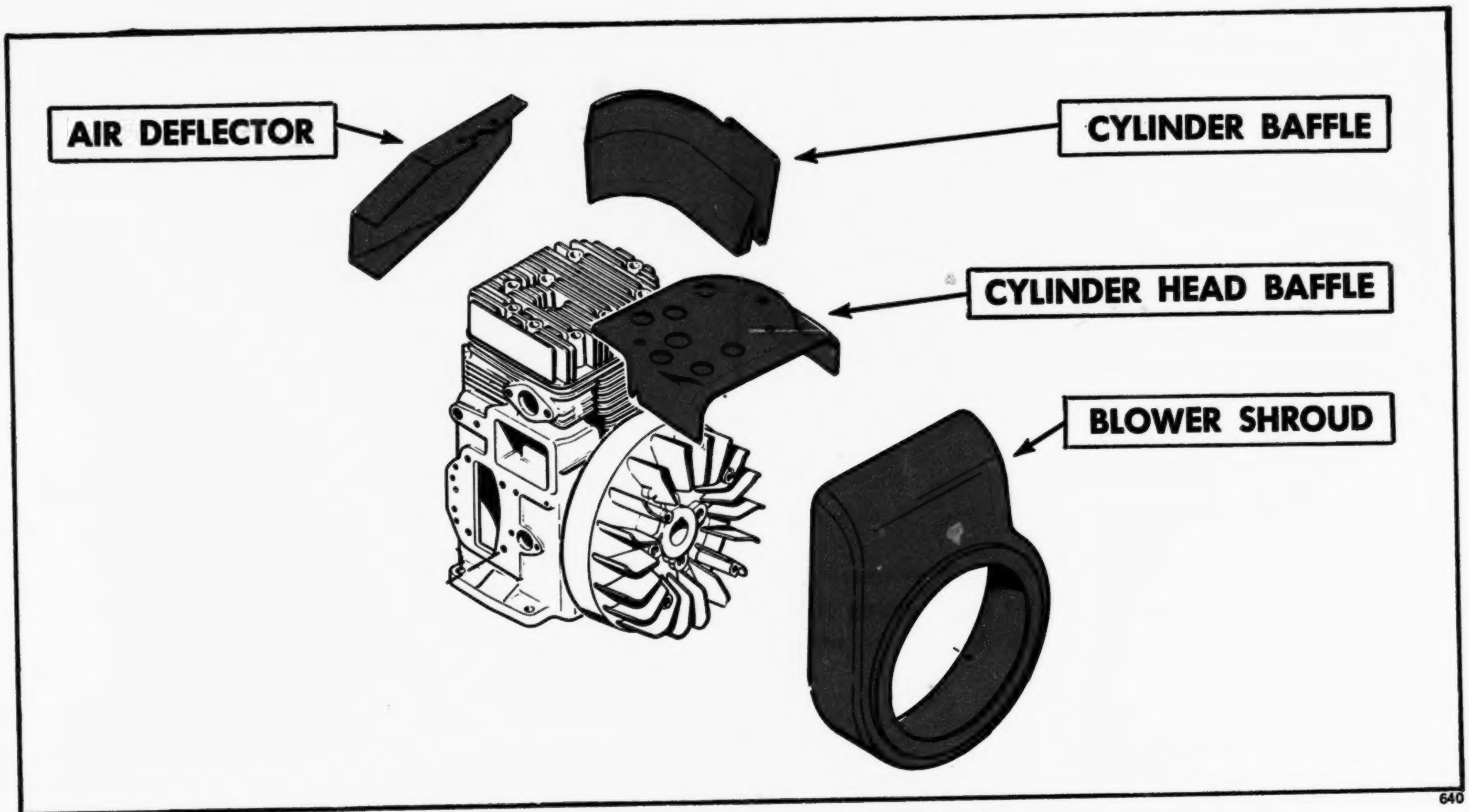

AIR DEFLECTOR
CYLINDER BAFFLE
CYLINDER HEAD BAFFLE
BLOWER SHROUD
640

FIGURE 26. Baffles, or deflectors, are used to divert air over the cylinder head.

6. *Clean inside of shroud and baffles.*

   Use a small bristle brush. A putty knife makes a good scraper for removing heavy accumulations of dirt (Figure 27).

7. *Clean intake screen (Figure 28).*

   Wash it in solvent.

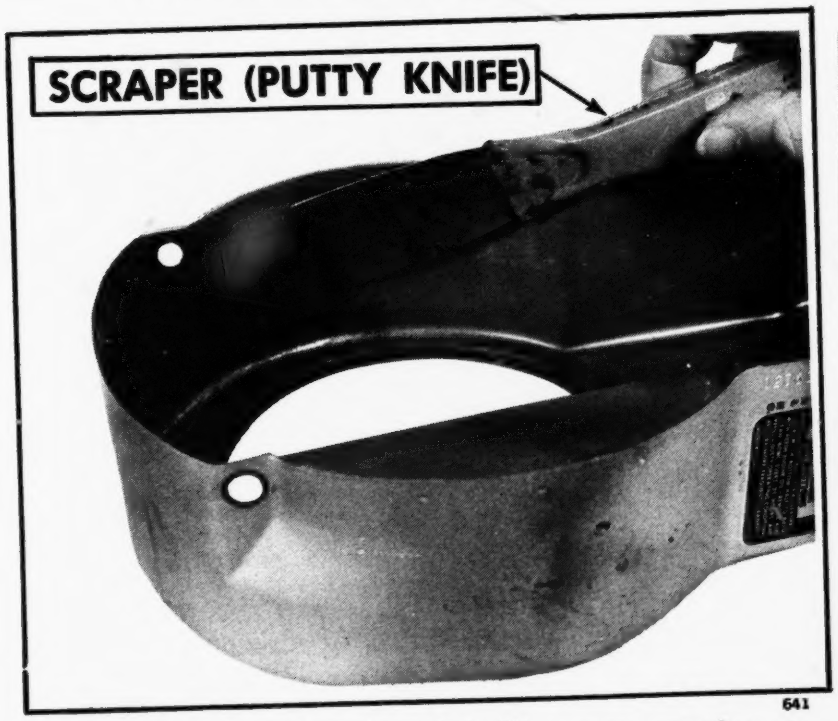

SCRAPER (PUTTY KNIFE)
641

FIGURE 27. The shroud and baffles may require removal of dirt with a putty knife if there are heavy accumulations.

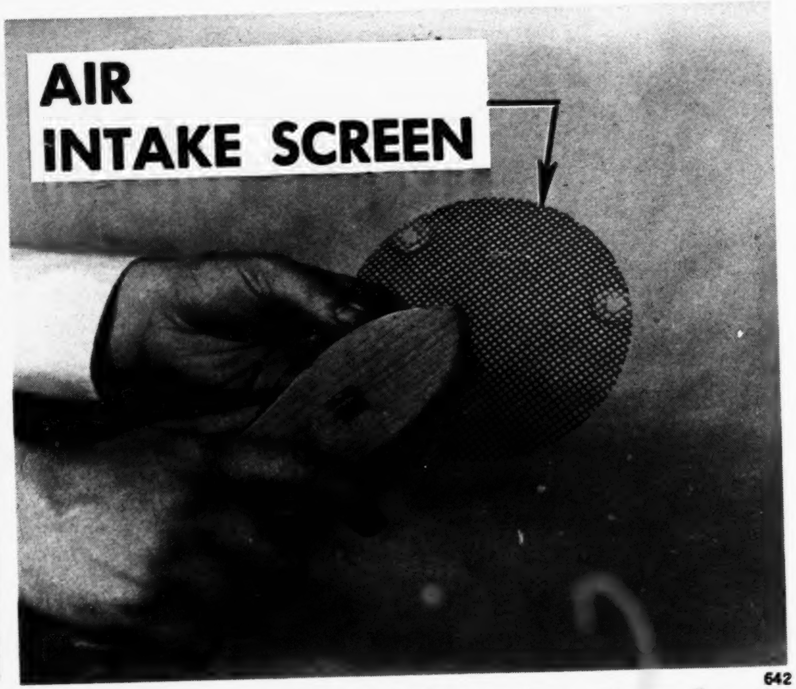

AIR
INTAKE SCREEN
642

FIGURE 28. Use a fiber bristle brush to clean deposits from screen.

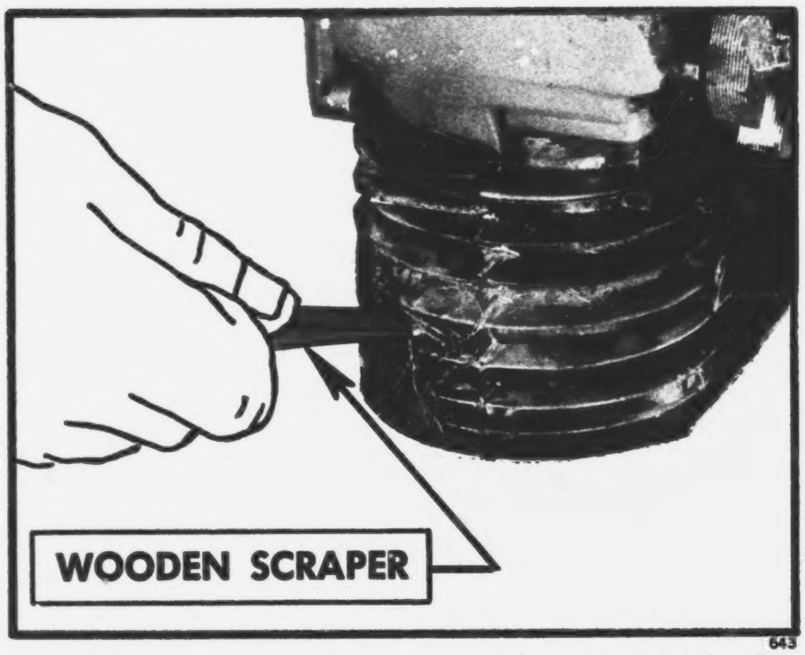


FIGURE 29. Use a wooden scraper for cleaning the fins on the cylinder head — especially if they are made of aluminum.

8. *Clean dirt from cylinder fins (Figure 29).*

   Use a wooden scraper. Steel scrapers scratch the finned surfaces, especially if they are made of aluminum. The scratches collect dirt.

9. *Clean dirt from blower flywheel fins.*

   Use same procedure as for cleaning dirt from cylinder head and fins.

10. *Inspect engine for cracks, blemishes and broken parts.*

    Inspect for dirt deposits on remote parts of engine, and straighten bent parts of baffles or shroud.

    Inspect the cylinder for cracks and broken cooling fins.

11. *Repeat the spraying and cleaning process.*

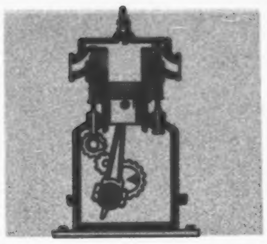
    Procedures are described in the previous section, "Cleaning and Inspecting the Crankcase and Accessories," page 25.

12. *Replace broken or damaged parts.*

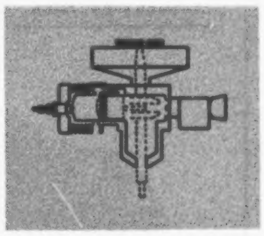
13. *Reassemble parts in reverse order.*

14. *Check nuts, screws, and bolts, including engine mounting bolts to make certain they are tight.*

15. *Repeat steps 10, 11, and 12 under the previous heading.*



C. SERVICING CARBURETOR AIR CLEANERS



The carburetor air cleaner filters the air going into your engine through the carburetor. Without it, dirt would soon ruin your engine.

The carburetor air cleaner is one of the most important parts of your engine. This was proved by one manufacturer who conducted an experiment to learn the effects of operating an engine under dirty conditions without an air cleaner. The engine failed after only *three and one-half hours* of operation. The cylinders, pistons, rings, and bearings were badly worn.

For the air cleaner to protect your engine from dirt, it must be serviced properly. Servicing consists principally of cleaning the filter element. Why it is important and how to service the air cleaner on your engine are discussed under the following headings:

1. Types of air cleaners and how they work.

2. Importance of servicing the air cleaner.
3. When to service the air cleaner.
4. Tools and materials needed.
5. Servicing the oil-bath type of air cleaner.
6. Servicing the oiled-filter type of air cleaner.
7. Servicing the dry-filter type of air cleaner.

TYPES OF AIR CLEANERS AND HOW THEY WORK

There are *three types of air cleaners* used on small gasoline engines. All three of them do a satisfactory job of removing harmful dirt from the air going into the engine—when serviced properly.

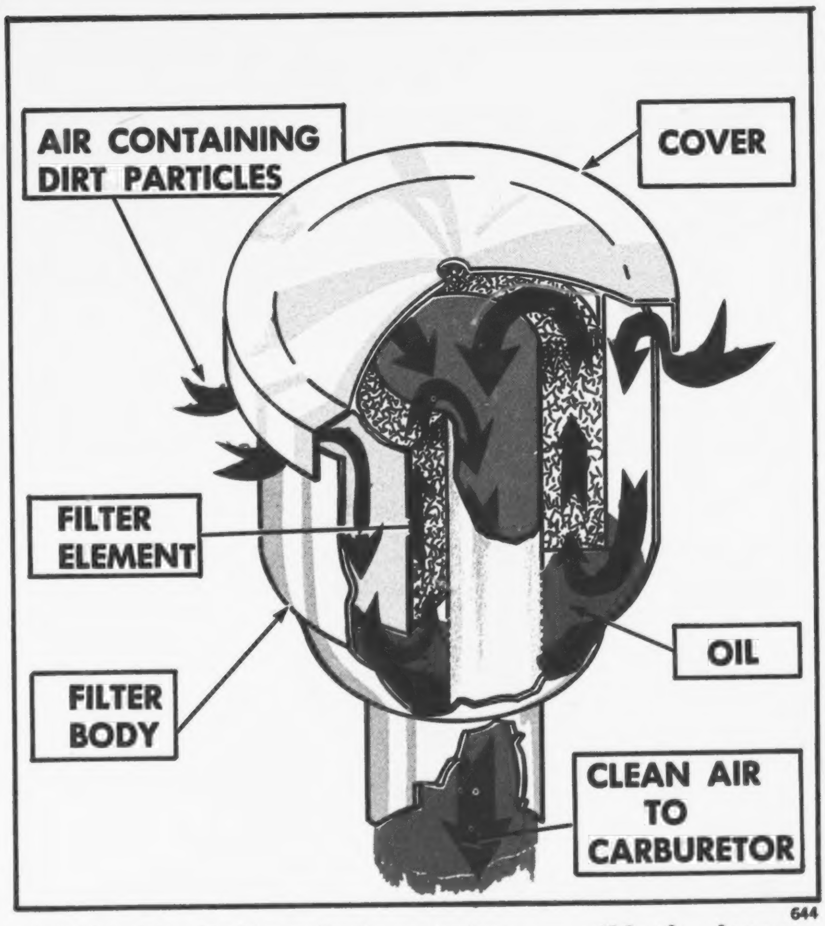


FIGURE 30. Unfiltered air entering an oil-bath cleaner is directed to an oil cup at the bottom of the cleaner assembly, up through a filtering element, and then down into the carburetor. Oil is picked up by the air in a fine mist and deposited on the metal-mesh filtering element. As the air moves up through the filtering element, the oil-coated dirt particles lodge in the filtering element. Excess oil and dirt drain back into the cup.

Air cleaners are of three types:

- Oil-bath type.
- Oiled-filter type.
- Dry-filter type.

It is important that you know how to identify your type of air cleaner and how it works, in order to use the proper procedures for servicing it.*

The **oil-bath type cleaner** washes dirt particles from the air by forcing it through a bath of oil (Figure 30).

Air enters the cleaner under the edge of the cover. It is directed downward to the bottom of the oil cup (Figure 30). When the air reaches this point, its path of travel changes abruptly to an upward movement.

Oil in the filter is picked up and carried along with the air. This action coats the dirt particles with oil and causes them to lodge in the mesh of the filtering element — a metallic maze.** As more dirt and oil collect in the filtering element, it drains back into the outer chamber of the oil cup. Here the dirt settles out, and the oil is used again to trap more dirt.

The **oiled-filter type of air cleaner** consists of a filtering material such as aluminum-foil mesh, or

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*A suggested engine inventory form, for individual use or class use, is shown on page 145 of the Appendix. When it is completed, it will be a convenient record to which you may refer when servicing your engine, making repairs or ordering parts. Complete the form as you learn to identify the different parts and accessories.

**The metallic mesh, or maze, is usually long strings of crimped metal, or fine wire, matted together. The object is to provide more oily surface over which the air will travel. The greater the surface, the more likely dirt will be picked up and prevented from entering the engine.

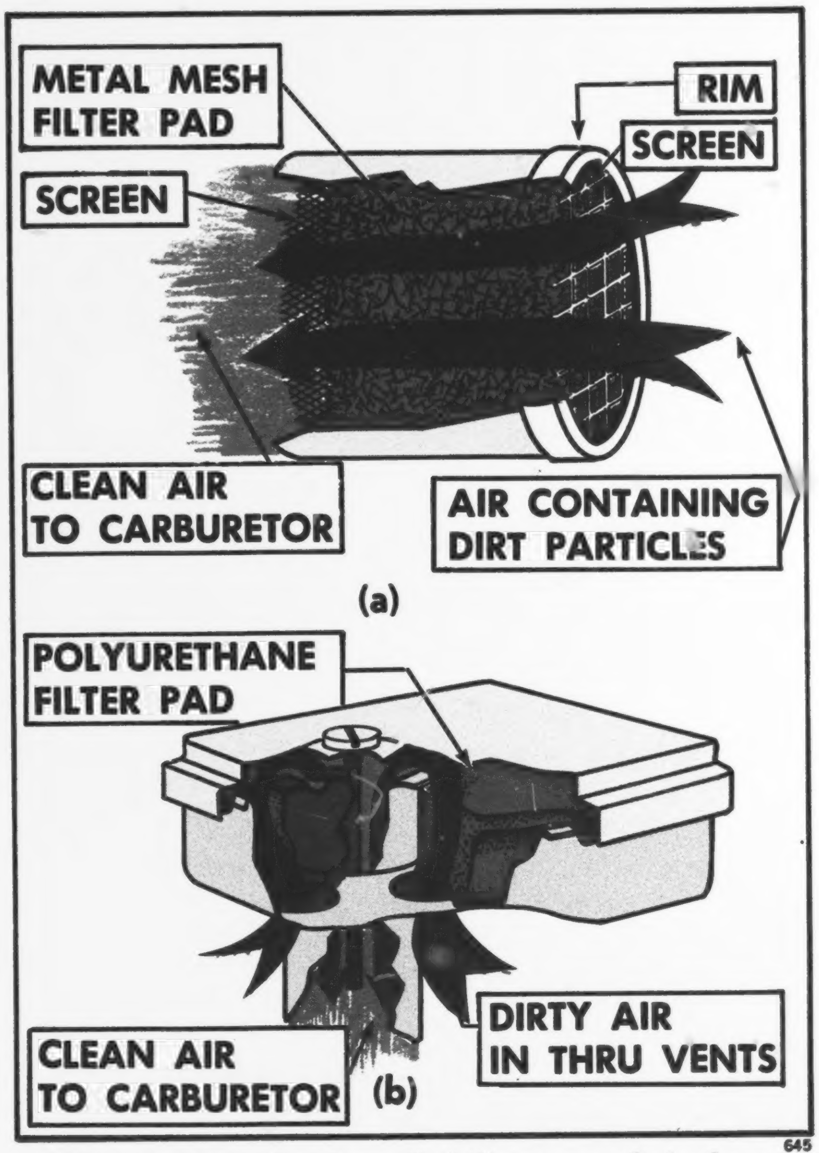
METAL MESH FILTER PAD
RIM
SCREEN
SCREEN
CLEAN AIR TO CARBURETOR
AIR CONTAINING DIRT PARTICLES
(a)
POLYURETHANE FILTER PAD
DIRTY AIR IN THRU VENTS
CLEAN AIR TO CARBURETOR
(b)
645

FIGURE 31. Principle of an oiled-filter type of air cleaner. Air going into the carburetor is forced to pass over the oiled surfaces of (a) a filter element (wad) of metal foil mesh, or (b) polyurethane. There is no oil reservoir as in the oil-bath type filter.

maze (Figure 31a), or a sponge-like plastic material called polyurethane (Figure 31b). Either material is coated with oil before being installed.

The filter is designed so the air passes over a large area of oiled surface. Oil on the filter material picks up dust and dirt particles and prevents them from going into the engine.

Many people think that oiling this type of filter is not necessary, but *without oil the filter is of no practical value.* Dirt goes right through it.

The **dry-filter type of air cleaner** (Figure 32) consists of a porous filtering element. It is usually made of paper, but some are made of moss or hair.

The dry-filter type air cleaner has a filter with minute (very small) openings that keep all except extremely small particles from passing through. This type of filter is *not dependent upon oil* for catching the dust and dirt.

Dry-filter cleaners have the following advantages:

- They are easier to service.
- Fuzz and chaff cause less restriction to air passage.
- They are more efficient at a wide range of engine speeds.
- When the air cleaner needs servicing, the engine warns you by failing to run properly. Dirt builds up on the filter, and the engine starves for air. This results in a choking effect.

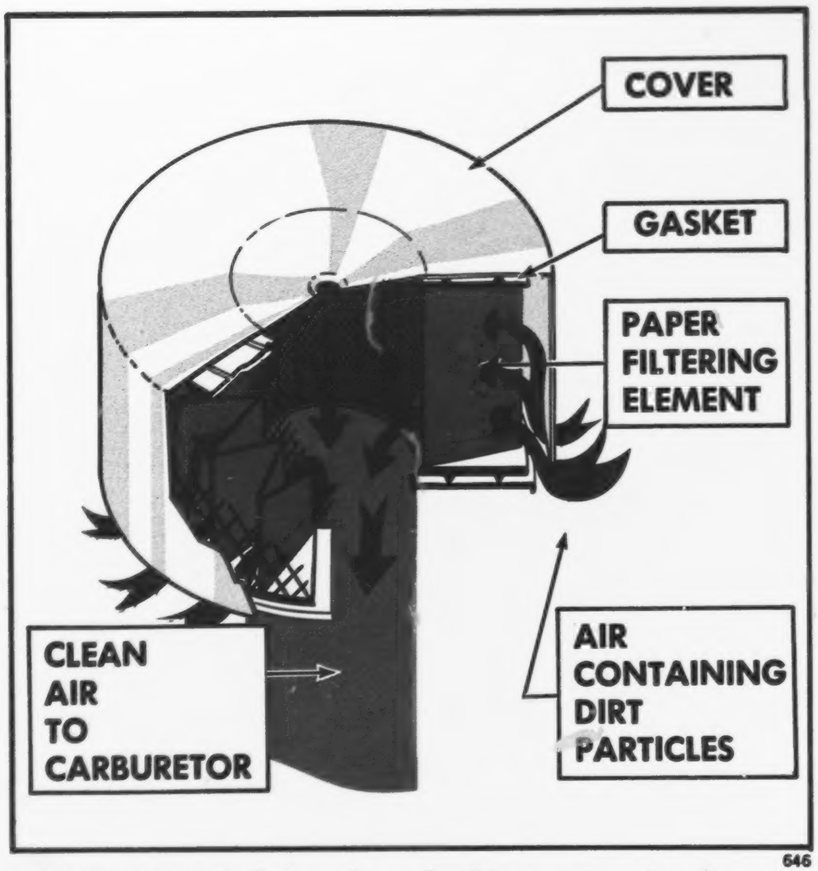
COVER
GASKET
PAPER FILTERING ELEMENT
CLEAN AIR TO CARBURETOR
AIR CONTAINING DIRT PARTICLES
646

FIGURE 32. Principle of a dry-filter type air cleaner. Air enters the cleaner and is forced to pass through the porous surface of the filter before going into the engine.

Dry-filter type air cleaners cost more to maintain than other cleaners because the filter element requires replacing quite often. How often depends upon the operating conditions.

IMPORTANCE OF SERVICING THE AIR CLEANER

A 3-horsepower engine operating at 3600 r.p.m. requires about 6½ cubic feet of air per minute (Figure 33a).

The purpose of this much air is to provide the best combustible (burning) mixture of gasoline and air.

Providing for this amount of air is no great problem with designers of small gasoline engines except that the air must be clean.

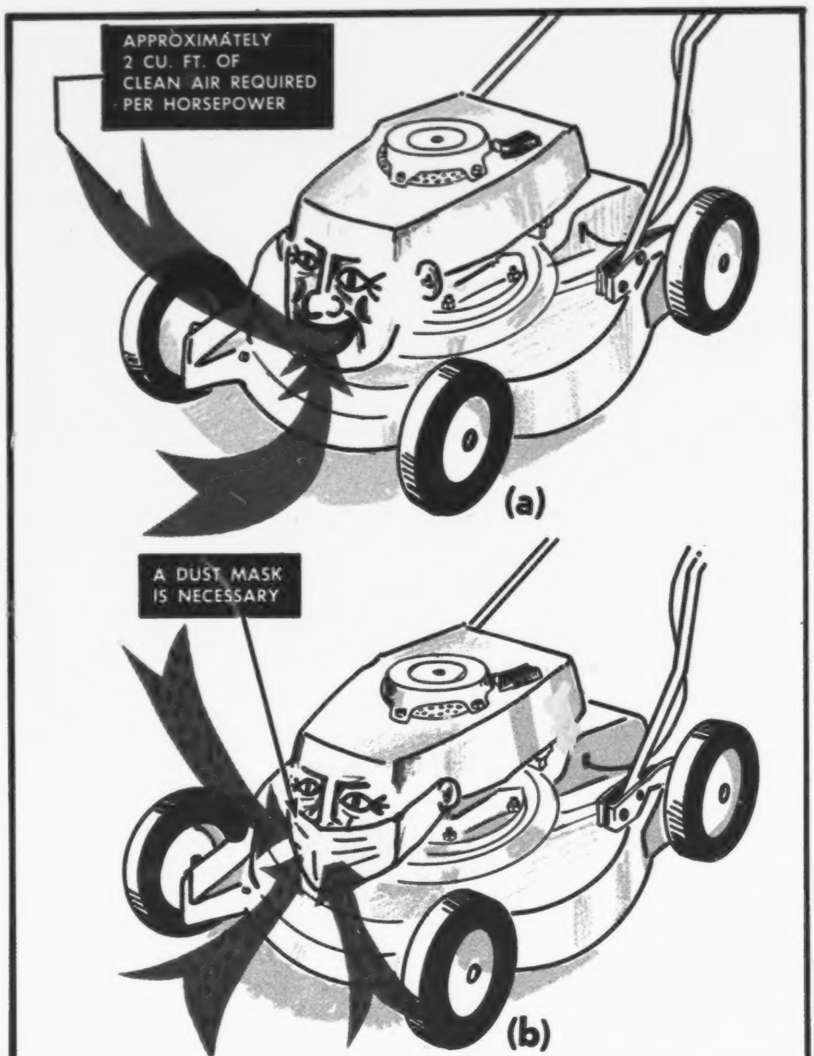

FIGURE 33. (a) Small engines require a large amount of air — approximately 2 cubic feet per horsepower per minute. (b) The air must be clean.

For this reason an air cleaner is added to the carburetor for filtering the air which goes into the engine (Figure 33b).

Providing protection from dirt is more difficult for small engines than for large engines because most small engines operate under the worst possible conditions—that is, near the ground and in dusty places.

The efficiency of the air cleaner, however, is limited, not by its design but by improper servicing. When they are serviced properly, all air cleaners are almost 100 per cent effective in filtering dirt from the air. But most people either fail to service air cleaners properly or do not service them often enough. They do not realize the importance of servicing.

If you fail to service your air cleaner properly, dirt and dust, which should be collected in the air cleaner, will either (1) pass into the engine and mix with the lubrication oil; or (2) it will build up on the air cleaner filter, choke the engine, and cause an excessively rich fuel-air mixture. Either condition will shorten the life of your engine.

If dirt gets past the air cleaner, it enters the combustion chamber. Some may be blown out through the muffler, but most of it passes by the cylinder wall where it mixes with oil in the crankcase to form a grinding compound instead of a lubricant.

If you allow the air cleaner to become severely clogged, you will get far too much fuel for the amount of air going into the cylinder. All the gasoline does not burn. The unburned gasoline washes the oil from the cylinder walls. Then *the piston and cylinder walls become scuffed and scored* from lack of lubrication. Fuel also enters the crankcase (4-cycle engines) and dilutes the lubricating oil.

A clogged air cleaner will choke the engine (either 4-cycle or 2-cycle). This choking results in *high fuel consumption, smoking, loss of power, and an excessive build-up of carbon deposits* in the combustion chamber. If choking is allowed to continue, the carbon deposits will cause *pre-ignition and overheating*. These conditions are described under "Refueling Small Engines," page 68.

The responsibility for servicing the air cleaner lies with the owner. No manufacturer will honor a warranty on an engine on which the air cleaner has been neglected.

You can avoid many of these problems and save yourself much trouble if you follow the engine manufacturer's suggestions for servicing the air cleaner.

WHEN TO SERVICE THE AIR CLEANER

It is difficult for manufacturers to say when an air cleaner should be serviced. Most of them recommend servicing the air cleaner **every 25 hours** if the engine is being operated under ideal conditions.

When the engine is operated continuously in **extremely dirty or dusty conditions,** there may be times when you will need to service the air cleaner *two or three times per day*. To be safe, inspect the air cleaner at least once each day—or before each use, if used regularly—until you determine the frequency needed for keeping it clean.

When you are operating a **chain saw** continuously, carry an extra clean filter for replacement. It is often impractical to clean the filter on the job; and it usually requires cleaning *twice each day*.

Procedures for servicing air cleaners vary with the different types. They are given under the headings that follow. You will also find instructions in your operator's manual or on a label stamped on the air cleaner.

TOOLS AND MATERIALS NEEDED

1. Slot-head screwdrivers — 4″ and 6″
2. Phillips-head screwdrivers — 4″ and 6″
3. Container for washing parts
4. Crankcase oil or special filter lubricant for polyurethane filters
5. Clean rags
6. Wooden scraper
7. Old paint brush
8. Petroleum solvent (mineral spirits, kerosene, or diesel fuel)

CAUTION: Do not use gasoline, naptha, or benzine. They are extremely flammable.

SERVICING THE OIL-BATH TYPE OF AIR CLEANER

1. *Disconnect the spark-plug wire.*

   This is a safety precaution which should be practiced each time you work on your engine. It is to prevent the engine from starting accidentally.

CAUTION! Never work on an engine while it is running. There is a danger of getting hurt by the moving parts.

WARNING! If you have a new engine which is equipped with an oil-bath type air cleaner, service it before operating the engine. Otherwise your engine will have no protection.

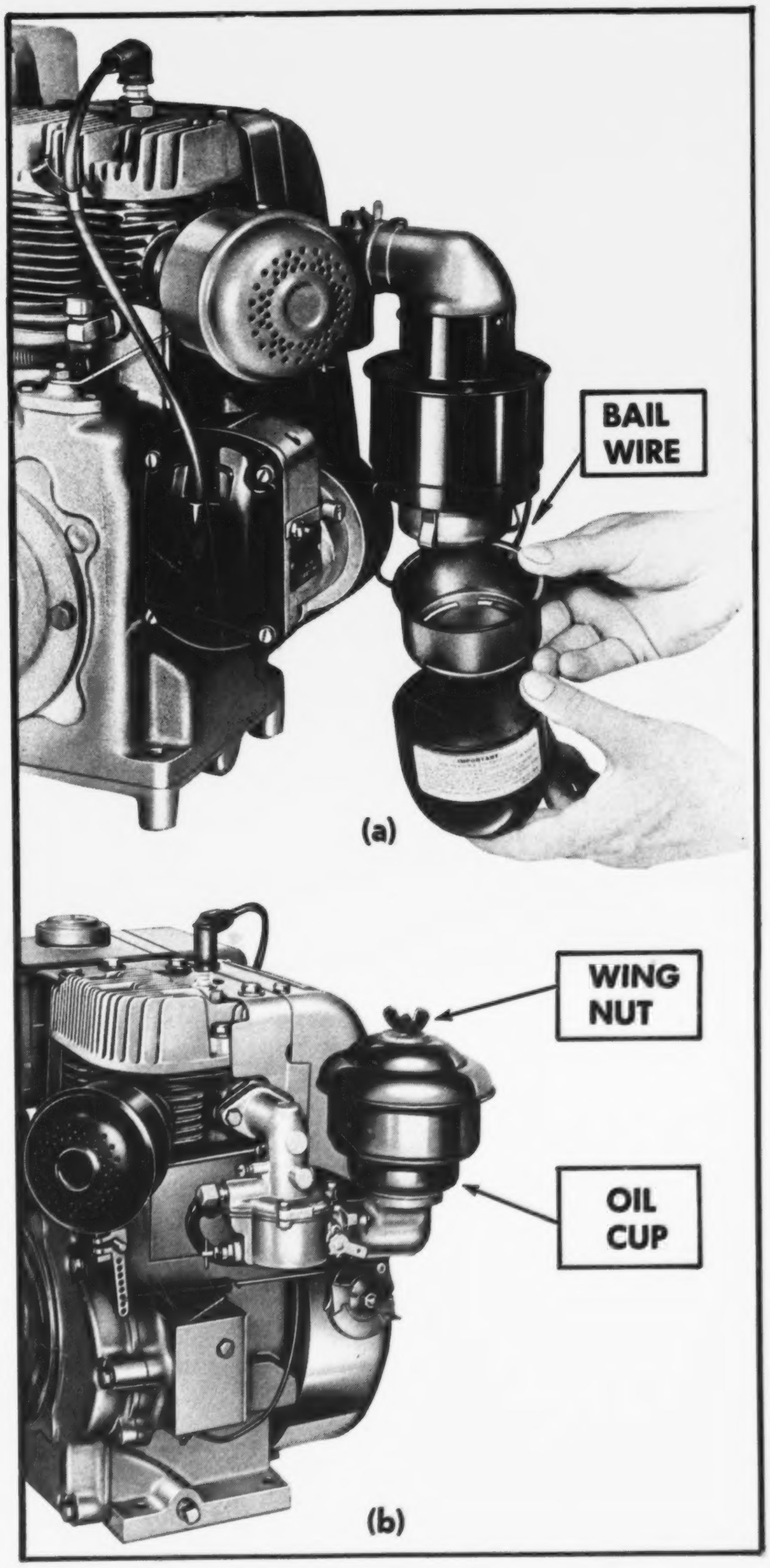

FIGURE 34. Most oil-bath air cleaners may be removed and disassembled without the use of tools. (a) Removing an oil cup which is secured by a bail wire. (b) Filter cover secured by a wing nut.

2. *Loosen oil cup, or cover, and remove the air cleaner (Figure 34).*

Do not try to remove the cleaner when the engine is running. This allows unfiltered air to enter directly into the engine. Also, you might get hurt by the moving parts on the engine.

If the cleaner is secured by a **bail wire** (Figure 34a), push the wire free by hand.

Hold onto the filter cup.

If the cleaner is secured by a **wing nut** (Figure 34b), you should be able to remove it by hand. If not, use a pair of pliers. Some are secured by nuts, or cap screws.

There is one type on which the cover has a **threaded stud** attached to the cover. It is removed by turning the cover.

3. *Cover the exposed air intake.*

There is a danger of dust blowing into it or of something falling into the opening. Cover it with a clean cloth or a plastic sheeting.

4. *Check depth of sediment deposit in bottom of oil cup (Figure 35).*

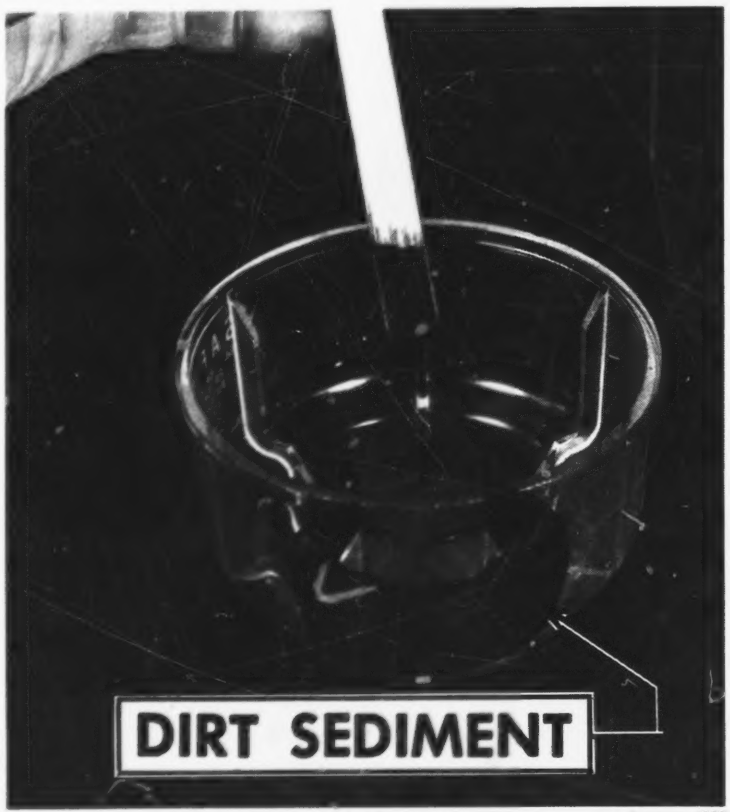

Figure 35. Use a clean stick to measure sediment deposit in oil cup.

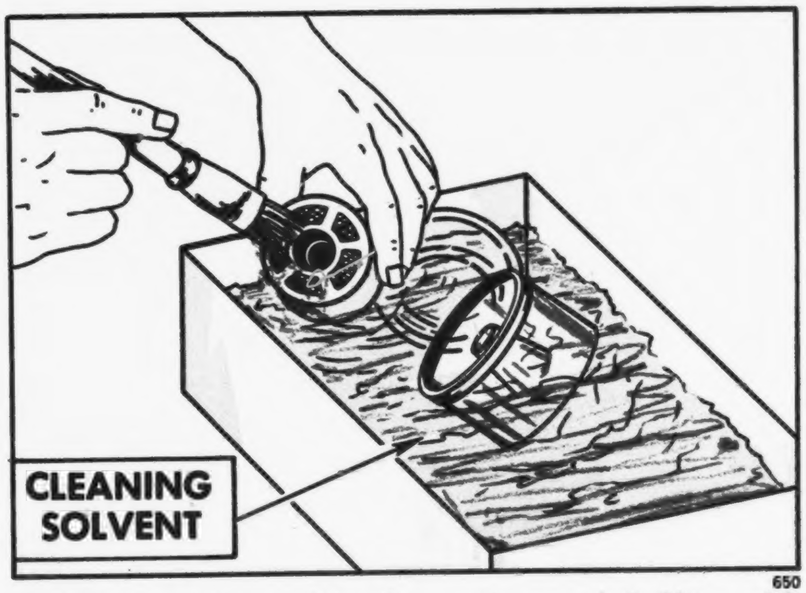

FIGURE 36. Thoroughly clean oil cup and filter with kerosene, mineral spirits, or diesel fuel.

If sediment deposit is as much as one-fourth inch deep, proceed with the remaining steps for servicing the air cleaner.

If the oil has thickened, even though the dirt depth may not be as much as one-fourth inch, change the oil. Thickened oil acts as a choke on your engine. It restricts the air intake and thus causes the engine to use more fuel. There is also a possibility of drawing dirt-laden oil into the carburetor.

If there is water in the cup, it is probably due to your leaving the engine in the rain. Change the oil. Water interferes with the cleaning action. It also causes hard starting and rough running.

5. *Throw away dirty oil.*

6. *Clean cup, filter, and other parts with petroleum solvent (Figure 36).*

   Remove all caked drit from bottom of cup.

   CAUTION! Do not use gasoline or other highly flammable mixtures such as naptha or benzine.

7. *Check air intake pipe to the carburetor for dirt accumulation.*

   This will not need cleaning often, but it is good practice to check it each time the oil cup is serviced.

   If it is dirty, swab it out with a clean cloth dampened with cleaning fluid.

8. *Refill cup with oil to "oil level" (Figure 37).*

   Most operators' manuals recommend using the same type and grade of oil as used in the engine crankcase for **4-cycle engines,** or the same oil that is mixed with the gasoline with **2-cycle engines.**

   An additive oil can be used, but it is of no particular benefit for this purpose.*

   If you use an **oil that is too heavy,** the splashing action is lessened. It also acts as a choke on the engine and increases fuel consumption.

   Oil that is too light may be pulled into the engine. This lowers the oil level in the cup until the cleaner is not efficient.

   Do not use **old crankcase oil.** It may con-

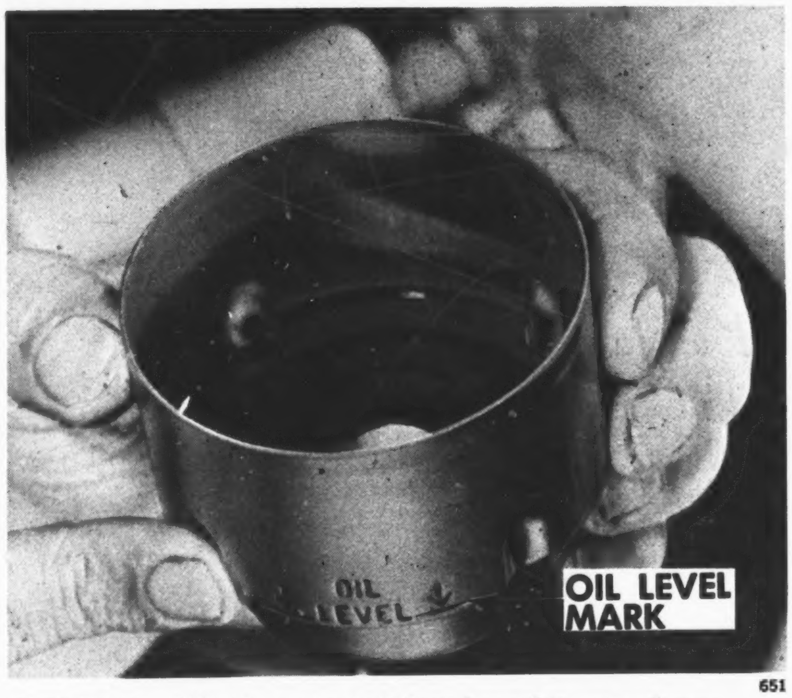

FIGURE 37. Fill oil cup to "oil level mark"—not above.

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*Additives are chemicals added to lubricating oil to give certain desired qualities such as resistance to foaming and corrosion, cleaning, and easy-pour properties at low temperatures. See "Lubricating Small Engines," page 57.

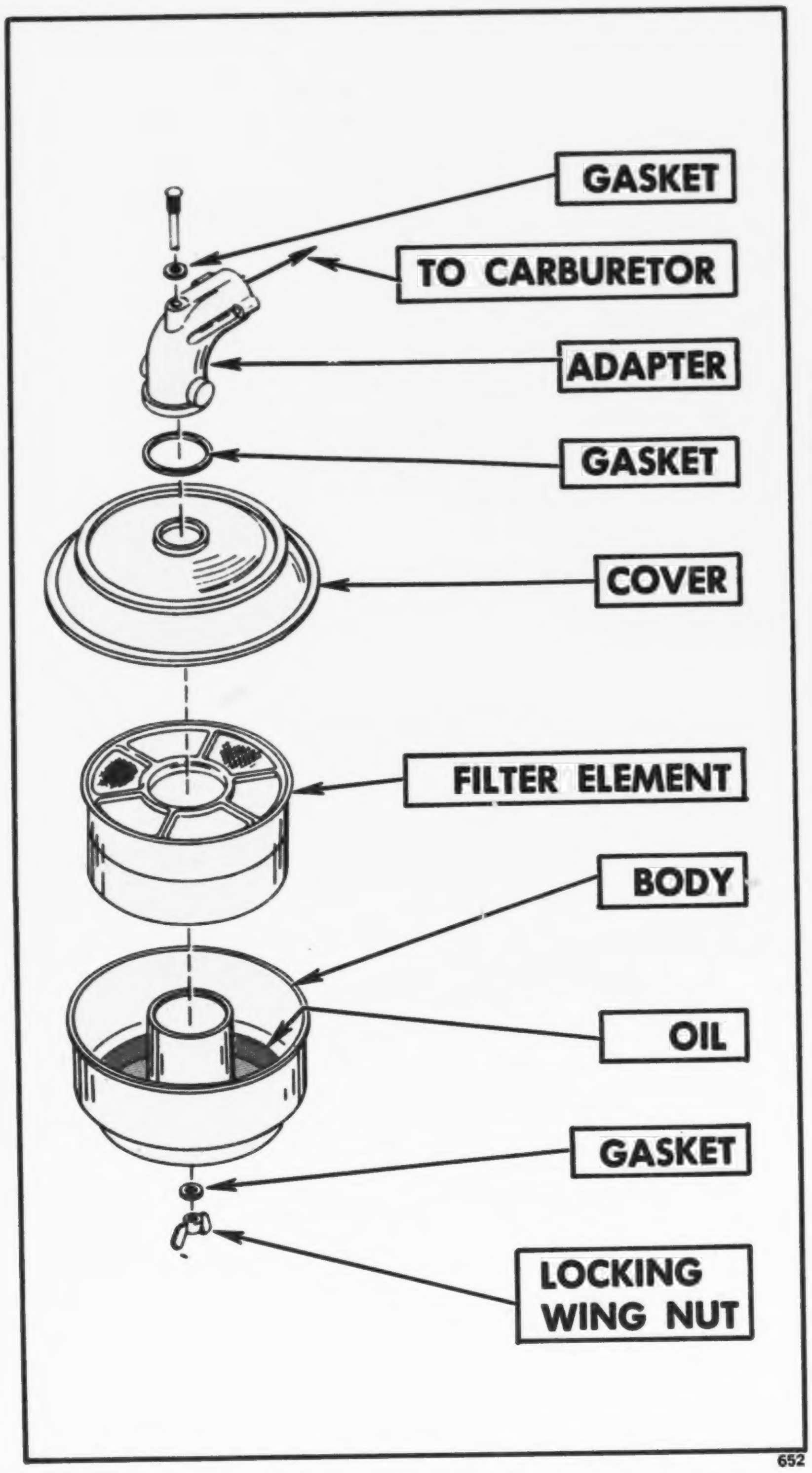

GASKET
TO CARBURETOR
ADAPTER
GASKET
COVER
FILTER ELEMENT
BODY
OIL
GASKET
LOCKING WING NUT
652

FIGURE 38. Assemble cleaner parts in proper order.

tain unburned fuel which evaporates quickly and lowers the oil level in the cup. It also contains dirt which limits washing action.

Do not **overfill the cup.** Overfilling restricts air passage through the oil. It may cause dirty oil to be pulled into the engine.

9. *Remove cover from intake.*
10. *Assemble the air cleaner, install, and tighten it (Figure 38).*

Be sure to replace all gaskets and to tighten all clamps. Air entering the engine through loose connections may by-pass the filter.

11. *Reconnect the spark-plug wire.*

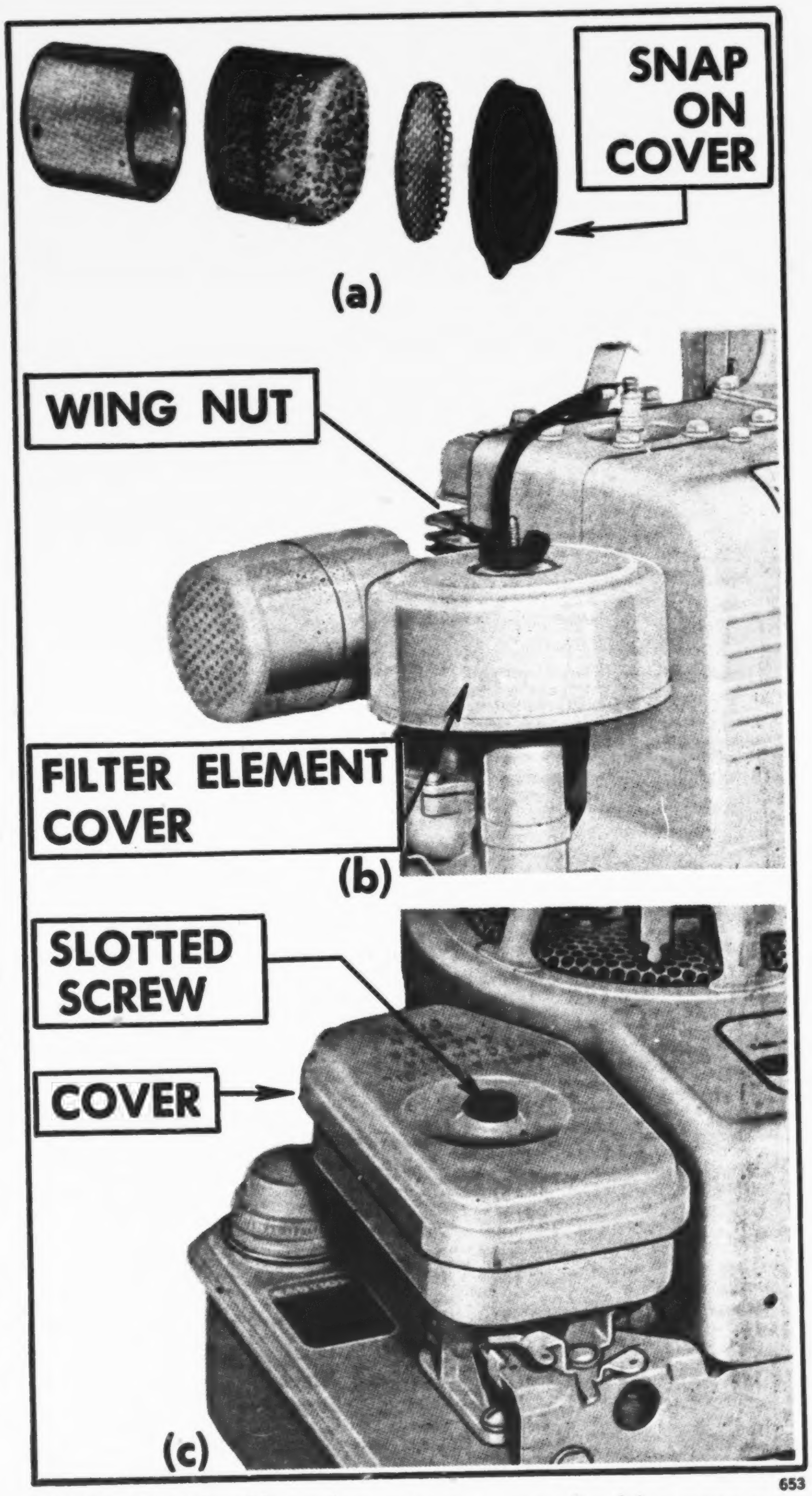

SNAP ON COVER
(a)
WING NUT
FILTER ELEMENT COVER
(b)
SLOTTED SCREW
COVER
(c)
653

FIGURE 39. The filter element cover may be (a) a snap-on cover, (b) secured by a winged nut, or (c) secured by one or more slotted screws.

SERVICING THE OILED-FILTER TYPE OF AIR CLEANER

1. *Disconnect the spark-plug wire.*

   This is to prevent the engine from starting accidentally.

2. *Clean area around the air cleaner.*

   This is to prevent loose dirt on the engine from getting into the carburetor air duct.

3. *Remove filter-element cover (Figure 39).*

4. *Remove filter element (Figure 40).*

   Be sure to note the order in which the parts are disassembled so you will be able to reassemble them in the proper order.

5. *Check condition of the filter element and other parts of the air cleaner.*

   Some polyurethane filters become brittle and crumble. When they get in this condition, they should be replaced. Replace all other damaged or broken parts.

6. *Cover carburetor air intake.*

   This is to prevent dirt from blowing or falling into the carburetor while the air cleaner filter is removed.

7. *Clean filter (Figure 41).*

   A strong solution of household detergent and hot water is best for cleaning **polyurethane filters.**

   CAUTION. Do not use gasoline for cleaning your air filter. Although some manufacturers recommend it, it is a serious fire hazard.

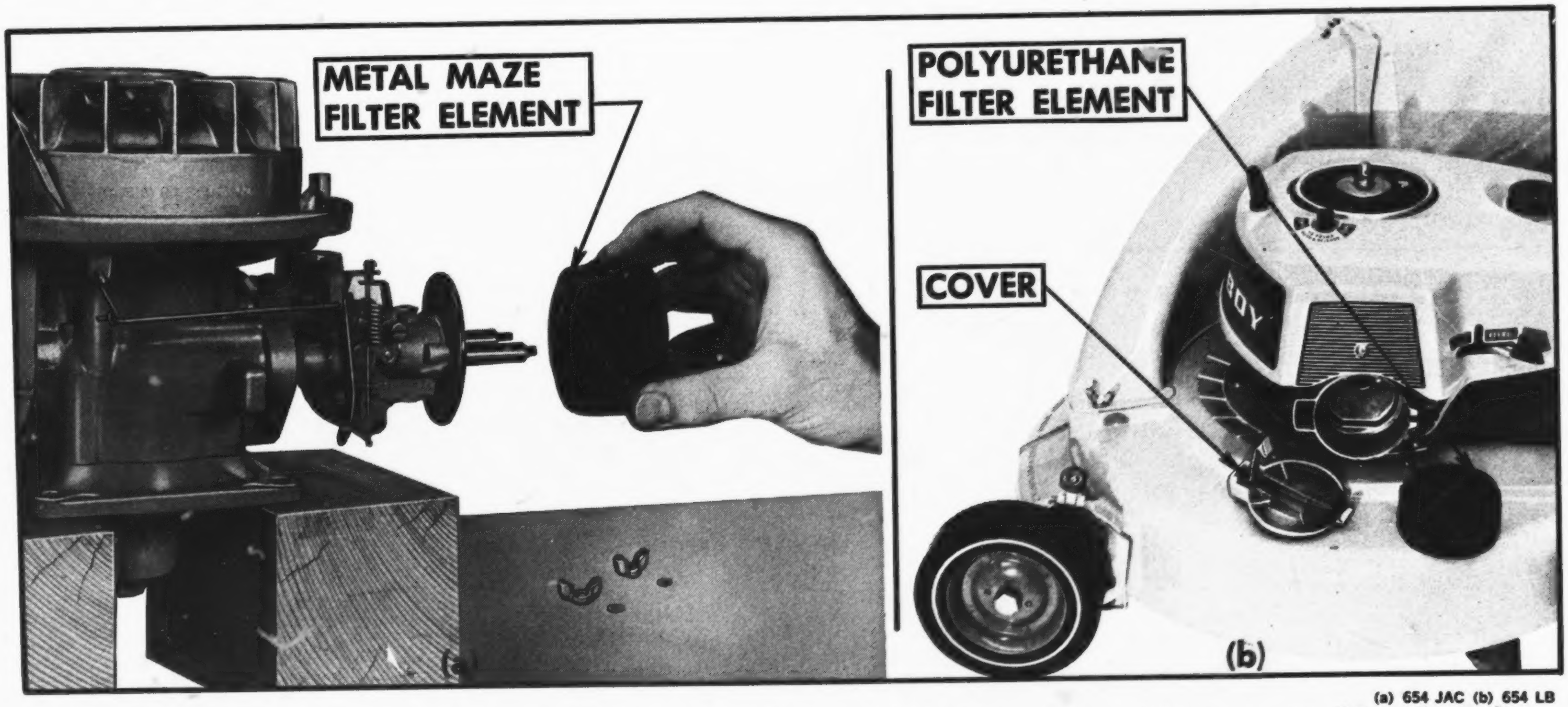
   Never use carbon tetrachloride or paint thinner. It dissolves certain glues in polyurethane filters. Also, when it is inhaled, carbon tetrachloride will make you sick.

   Some manufacturers recommend using petroleum solvent, which is fairly satisfactory for both types of filter elements.

   Clean the housing and cover with a stiff bristled brush, do not leave any loose bristles in the air cleaner.

8. *Dry the filter element (Figure 42).*

   If your filter is the **polyurethane-sponge type,** dry it by squeezing (Figure 42a) and by using compressed air.



(a) 654 JAC (b) 654 LB

FIGURE 40. The filter element of an oiled-filter air cleaner may be either: (a) metal maze, or (b) polyurethane (plastic) sponge.

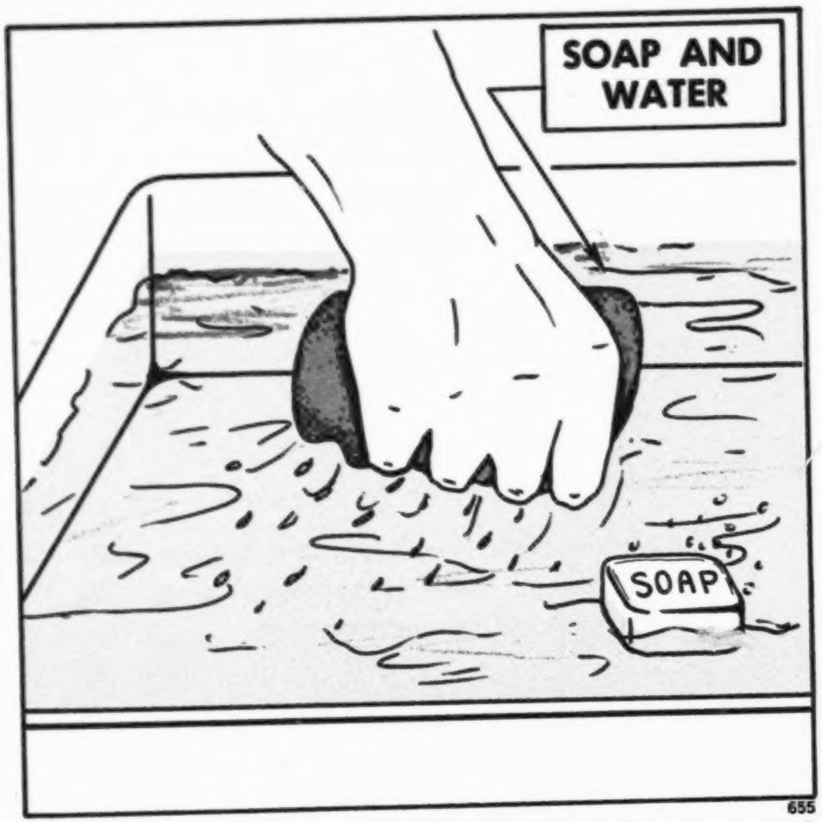


FIGURE 41. Cleaning a polyurethane filter with soap and water.

If your filter is the **metal-mesh type,** dry it by swishing it in the air or by using compressed air (Figure 42b and c).

9. *Remove the protective cover from the carburetor intake.*

10. *Clean the carburetor intake.*

    Use a clean cloth dampened with solvent.

11. *Oil the filter element.*

    Oiling the filter element is important. Many people neglect this because it is messy and because they think it is not needed. The oiled surfaces, however, are what catch the dirt.

    Use the same grade and type of oil used in your engine crankcase or special oil provided by your manufacturer.

    Oil must be well distributed throughout the element for proper filtering action.

    For **polyurethane filters,** manufacturers recommend using one, two, or three tablespoons of oil. This depends on the size of the filter element. Squeeze it several times to insure an even distribution of oil.

    If you have a **metal mesh filter,** dip it into oil and swish out the excess oil.

    If you use *oil that is too thick,* it will choke the engine.

    If you use *oil that is too thin,* some of it will be drawn into the engine; and the filter will not stop the dirt.

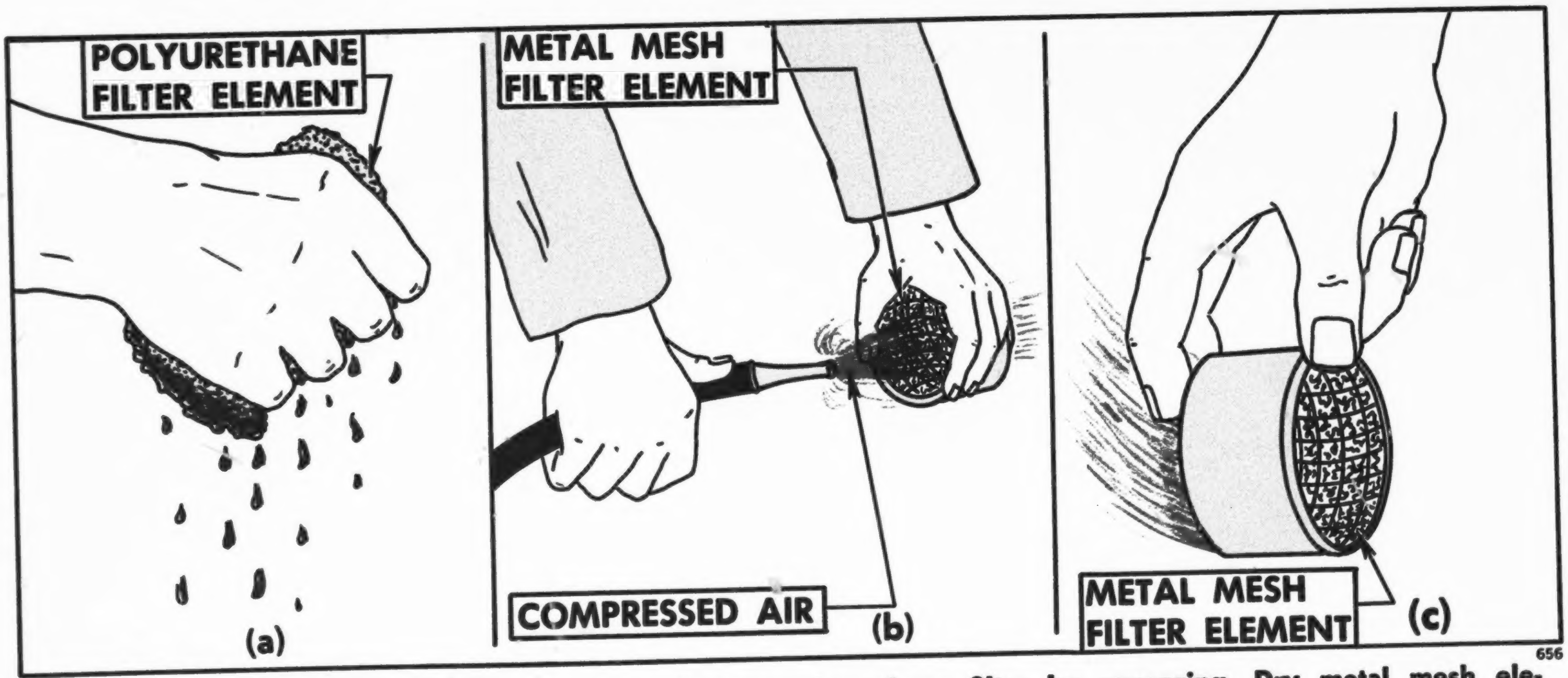

POLYURETHANE FILTER ELEMENT
METAL MESH FILTER ELEMENT
COMPRESSED AIR
METAL MESH FILTER ELEMENT
(a)
(b)
(c)
656

FIGURE 42. Methods for drying filter elements. (a) Dry polyurethane filter by squeezing. Dry metal mesh element by (b) compressed air or (c) by swishing.

If you use *too much oil,* it will be drawn into the engine and tend to foul the spark plug.

12. *Install filter element.*

Some polyurethane filters come in two sections—a coarse filter on the outside and a fine filter next to the carburetor. The coarse filter stops larger particles and prevents early clogging. The fine filter removes most of the smaller particles.

13. *Install cover.*

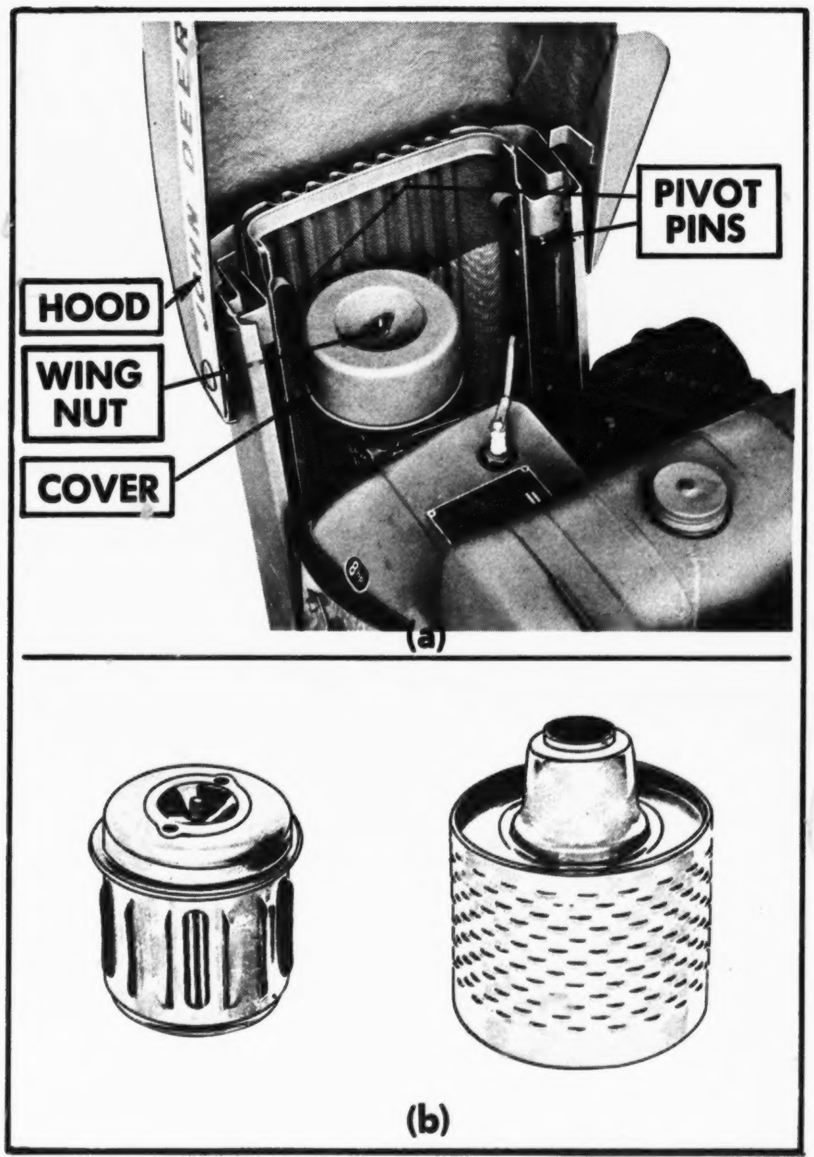
Reassemble in reverse order of disassembly. Tighten wing nuts finger tight.

14. *Reconnect spark-plug wire.*

SERVICING THE DRY-FILTER TYPE OF AIR CLEANER

1. *Disconnect the spark-plug wire.*

This prevents the engine from accidentally starting.



(a) 657 JD

FIGURE 43. Dry-filter type air cleaners may be protected by (a) a cover secured by a wing nut or (b) they may be self-contained cartridges—the filter and container built as a unit.

CAUTION! Never work on your engine while it is running. There is a danger of getting caught in some fast-moving part.

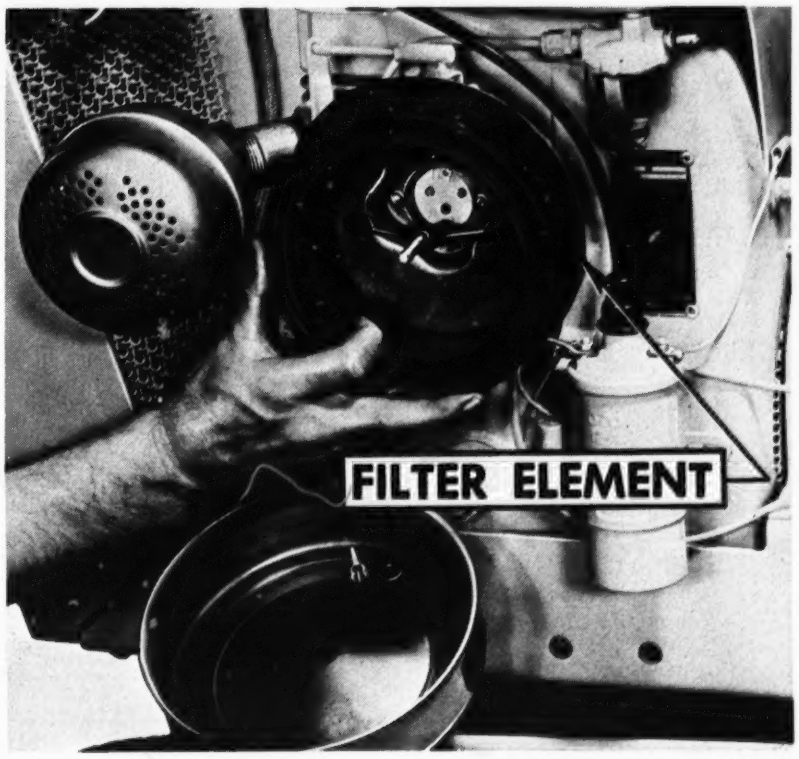
2. *Clean the area around the air cleaner.*

This cleaning prevents surface dirt from falling into the carburetor intake.

3. *Remove the filter element cover (Figure 43a).*

Some dry-filter type air cleaners are made in one piece (self-contained) and are attached by a stud bolt. There is no removable cover.

4. *Remove the air filter element (Figure 44).*



658 IHC

FIGURE 44. Removing paper filter element.

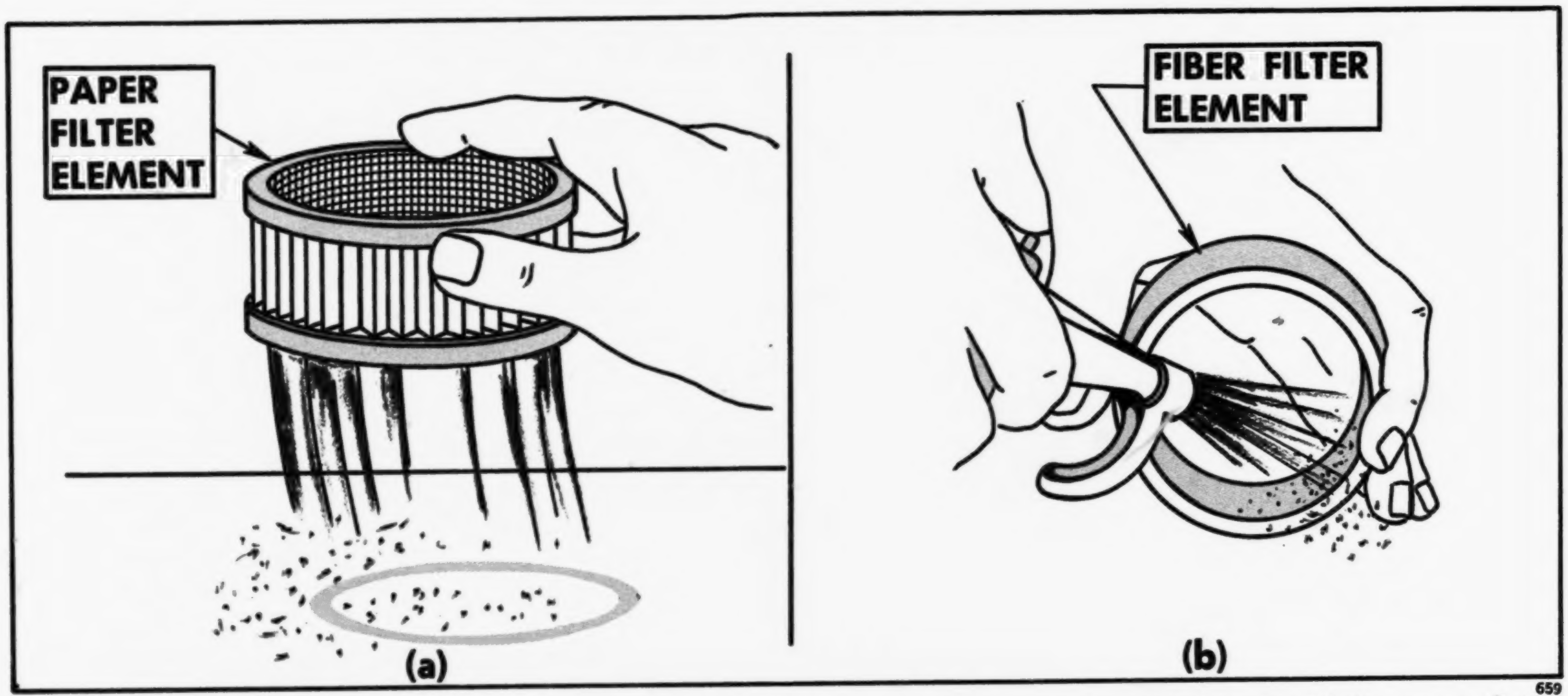


FIGURE 45. Methods for cleaning filter elements. (a) Clean paper element by tapping it lightly on a flat, hard surface. (b) Clean fiber element by directing compressed air from the inside out.

5. *Cover the carburetor air intake with cloth or plastic.*

   This covering prevents dirt from blowing or falling into carburetor intake.

6. *Check condition of filter element and other parts.*

   Replace if damaged.

7. *Clean air filter element (Figure 45).*

   If your filter **element is paper,** clean by tapping it on a flat surface (Figure 45a).

   Do not wash it unless instructed to do so by the manufacturer. The open pores in some filter elements will close.

   Replace paper elements if the dust does not drop off easily during or after tapping—or if it is bent, crushed, or damaged.

   Handle paper element with care. One small hole in the filter may be as bad as no filter at all.

   Do not use compressed air. It may rupture the filter.

   If your filter **element is moss or fiber,** direct compressed air from the inside out (Figure 45b). Wash it in soap and water. Petroleum solvents are too oily.

   Note: Do not put oil on a dry type filter. It clogs the pores in the paper, and air will not be able to pass through.

8. *Remove protective cover from the carburetor intake.*

9. *Clean filter cover and carburetor intake.*

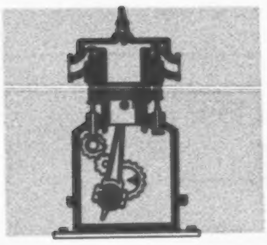
   Wipe with a clean cloth dampened with cleaning solvent.

10. *Replace filter element.*

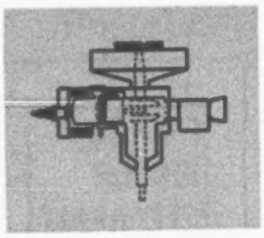
    Be sure the filter fits snugly around the air-cleaner base to prevent unfiltered air from by-passing the filter element. Install gasket if one is used.

11. *Replace cover.*

    Tighten wing nut(s) finger tight.



D. SERVICING FUEL STRAINERS



The fuel strainer may be located between the fuel tank and the carburetor, or inside the fuel tank. Its purpose is to help prevent dirt and trash from entering the engine through the fuel system. If the fuel strainer becomes clogged, the engine does not receive the proper amount of fuel. Just how often fuel strainers are likely to become clogged is difficult to determine.

It is generally recommended that you check the fuel strainers after approximately **25 hours of operation.**

Fuel strainers on **chain saws** which are operated regularly, usually require cleaning as often as *once each week.*

If your engine is equipped with a glass sediment bowl and strainer (Figure 46a), it is a simple matter to make a visual check daily to see if it needs cleaning.

Procedures for servicing fuel strainers are given under the following headings:

1. Types of fuel strainers.
2. Importance of servicing the fuel strainer.
3. Tools and materials needed.
4. Servicing the sediment-bowl type of fuel strainer.
5. Servicing the screen-type of fuel strainer.

TYPES OF FUEL STRAINERS

There are three types of fuel strainers common to small gasoline engines:

- A combination screen and sediment bowl (Figure 46a).
- A screen in the fuel tank, attached either to the fuel shut-off valve or to the fuel-line tank fitting if there is no shut-off valve (Figure 46b).
- A screen, or some other type strainer, attached to the end of a fuel pick-up hose in the fuel tank (Figure 46c).

The most effective fuel filter is the **combination screen and sediment bowl** (Figure 46a). Because of the initial cost, however, these filters are used only on larger engines or in heavy-duty applications where the engine is to be operated continuously in a stationary position.

The purpose of the glass bowl is to allow water and sediment to settle out. Water and dirt are both heavier than gasoline. Since the operation of this type of fuel strainer depends on gravity, it cannot be used on engines which operate in multi-positions such as chain saws.

An engine without a screen-and-sediment-bowl type of strainer has a **screen in the fuel tank** (Figure 45b). The most common is a fine wire screen attached to the fuel shut-off valve or to the fuel inlet line.

On engines that operate in any position, such as chain saws, the **strainer may be attached to**

the end of a flexible hose (Figure 45c.) The strainer end is weighted so that the pick-up end will move to the lowest point in the fuel tank. With this arrangement the end of the hose remains in the fuel supply regardless of the angle at which the engine is tilted.

In addition to a fuel strainer the *carburetor may also have a screen* for filtering dirt from the fuel.

Before servicing the fuel strainer on your engine, you will need to know which of these three types is used.*

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*Fill in the information in your inventory form, Appendix, page 145.

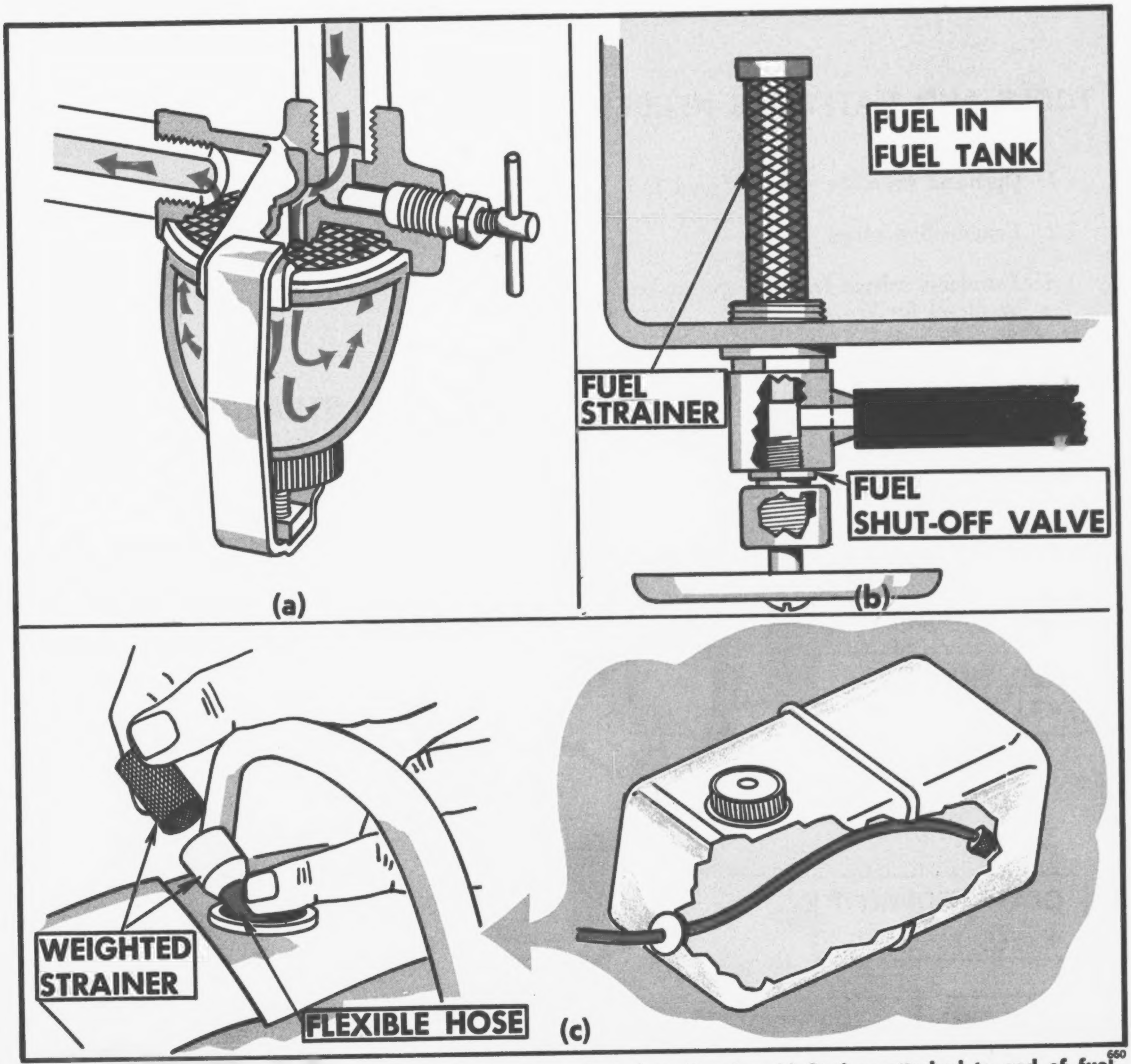

(a)
FUEL IN
FUEL TANK
FUEL
STRAINER
FUEL
SHUT-OFF VALVE
(b)
WEIGHTED
STRAINER
FLEXIBLE HOSE
(c)
660

FIGURE 46. Types of fuel strainers used on small gasoline engines. (a) Glass sediment bowl and screen usually attached under fuel tank. (b) Screen in fuel tank attached to fuel shut-off valve. (c) Strainer attached to end of fuel pick-up hose for engines which operate at any angle.

IMPORTANCE OF SERVICING THE FUEL STRAINER

If you fail to keep the fuel strainer clean, it will clog and starve your engine of fuel. It may not start. If it does, it will run rough and erratic, and may even stop.

An engine will not perform well with dirt or trash in the gasoline. Here is the reason. Gasoline is metered at the carburetor through small needle-valve jets. The jets regulate the amount of gasoline flow to give the proper fuel-air mixture. A few fine particles of solid materials can clog the carburetor jets and cause the engine to skip or fail to run.

TOOLS AND MATERIALS NEEDED

1. Open-end wrenches — 7/16″ and 1/2″
2. Combination pliers — 7″
3. Petroleum solvent (mineral spirits, kerosene, or diesel fuel)
4. Pan for cleaning parts in solvent
5. Cleaning rags
6. New gasket for glass bowl

SERVICING THE SEDIMENT-BOWL TYPE OF FUEL STRAINER

1. *Disconnect the spark plug wire.*

   This is to prevent the engine from starting accidentally.

2. *Close fuel shut-off valve (Figure 47).*

   This stops fuel flow from the tank.

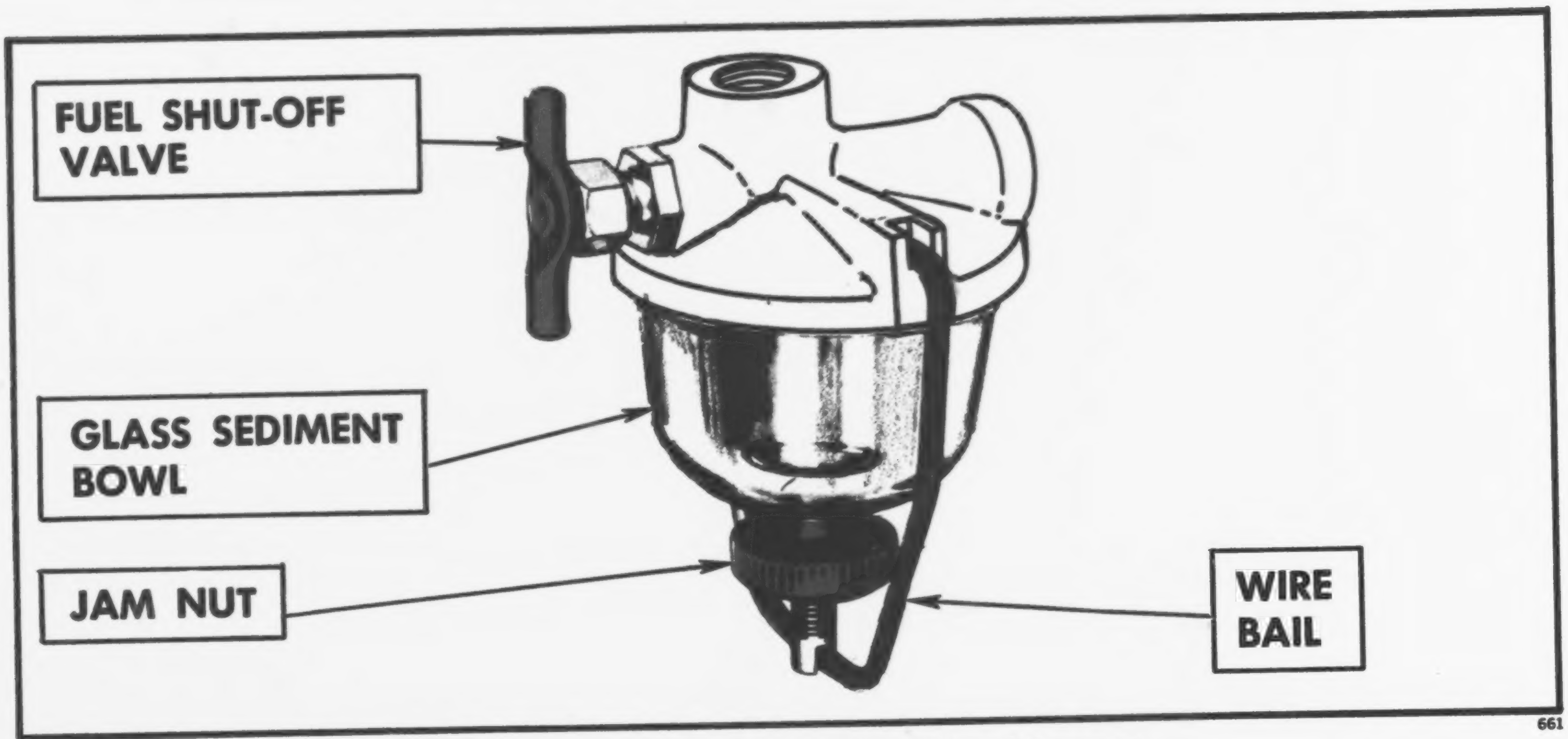


FIGURE 47. Most sediment bowls are held in place by a wire bail and jam nut.

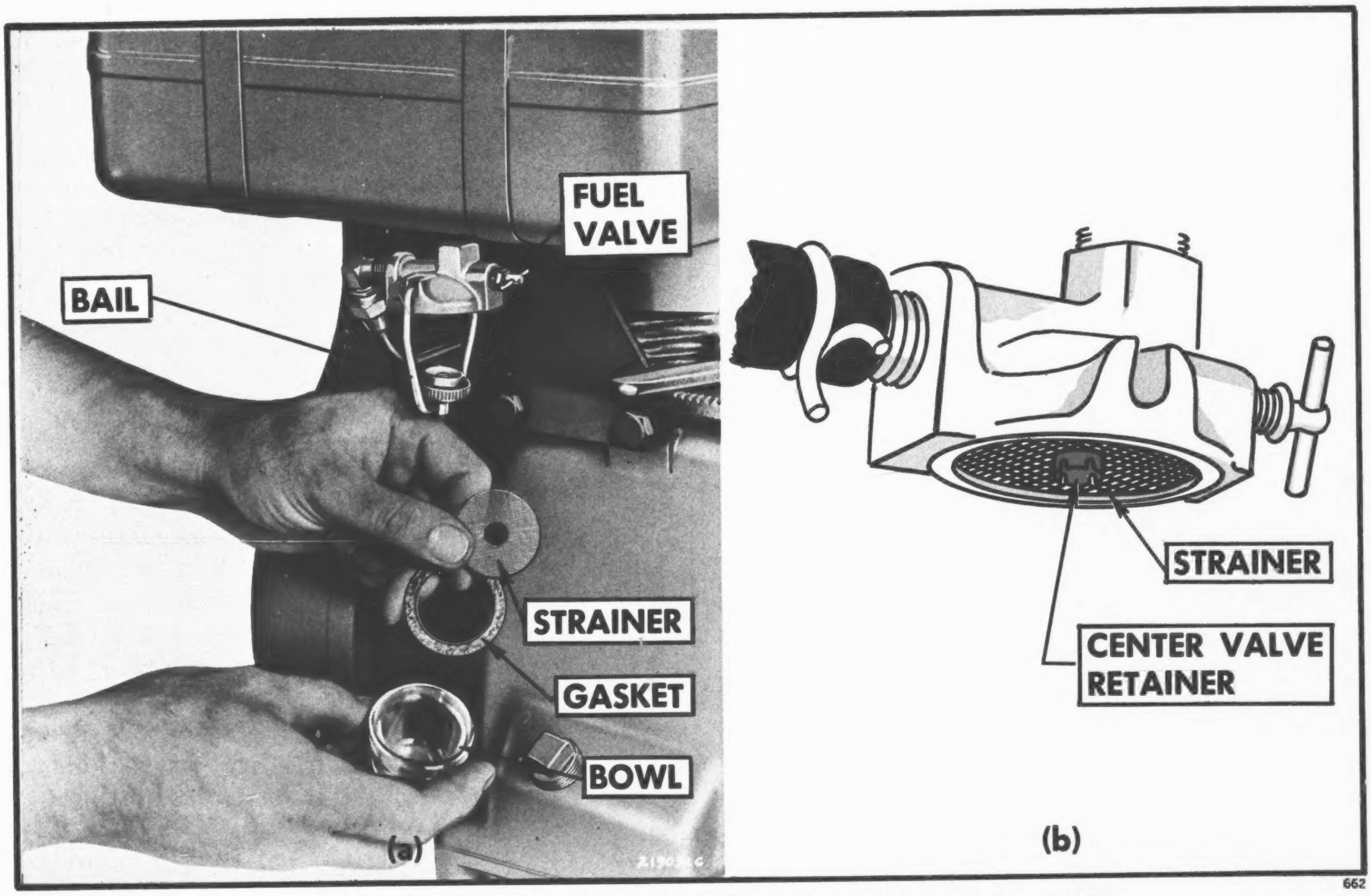


FIGURE 48. (a) Removing glass bowl and fuel strainer assembly. (b) Fuel strainer in position.

3. *Loosen jam nut and swing the wire bail to one side (Figure 47).*

4. *Remove bowl with a twisting motion.*

   There is less danger of breaking the cork gasket that forms a seal between the bowl and bowl housing if it is twisted while being removed.

5. *Remove gasket (Figure 48a).*

6. *Remove strainer (filter) screen (Figure 48).*

   The screen is usually removed from the top of the sediment bowl, since it is held in place by clamping action between the bowl and the gasket (Figure 48a). Some, however, do not come off with the bowl. They have to be pried from the center retainer (Figure 48b). The retainer is a friction clip over which the center of the strainer fits.

7. *Wash the screen, or filter element (Figure 49).*

   Be careful not to damage the screen.

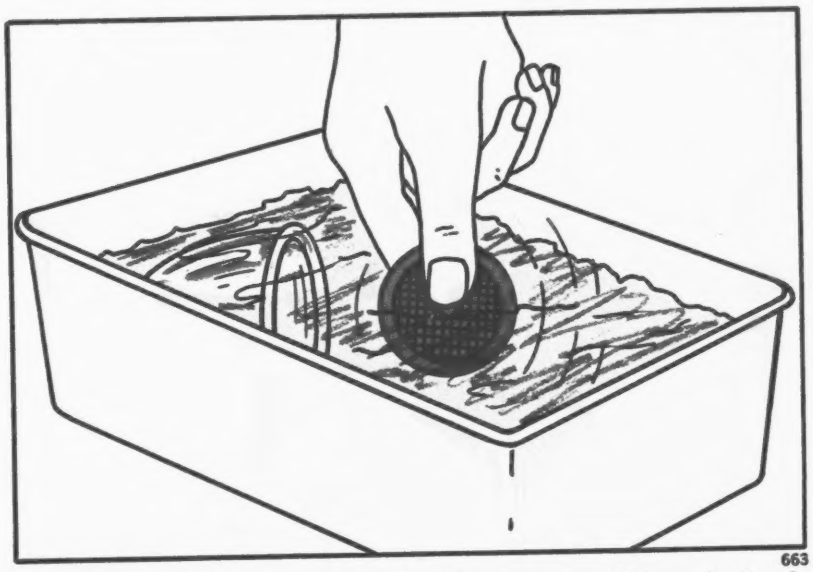


FIGURE 49. Clean screened filter by swishing it back and forth in clean kerosene, mineral spirits, or diesel fuel.

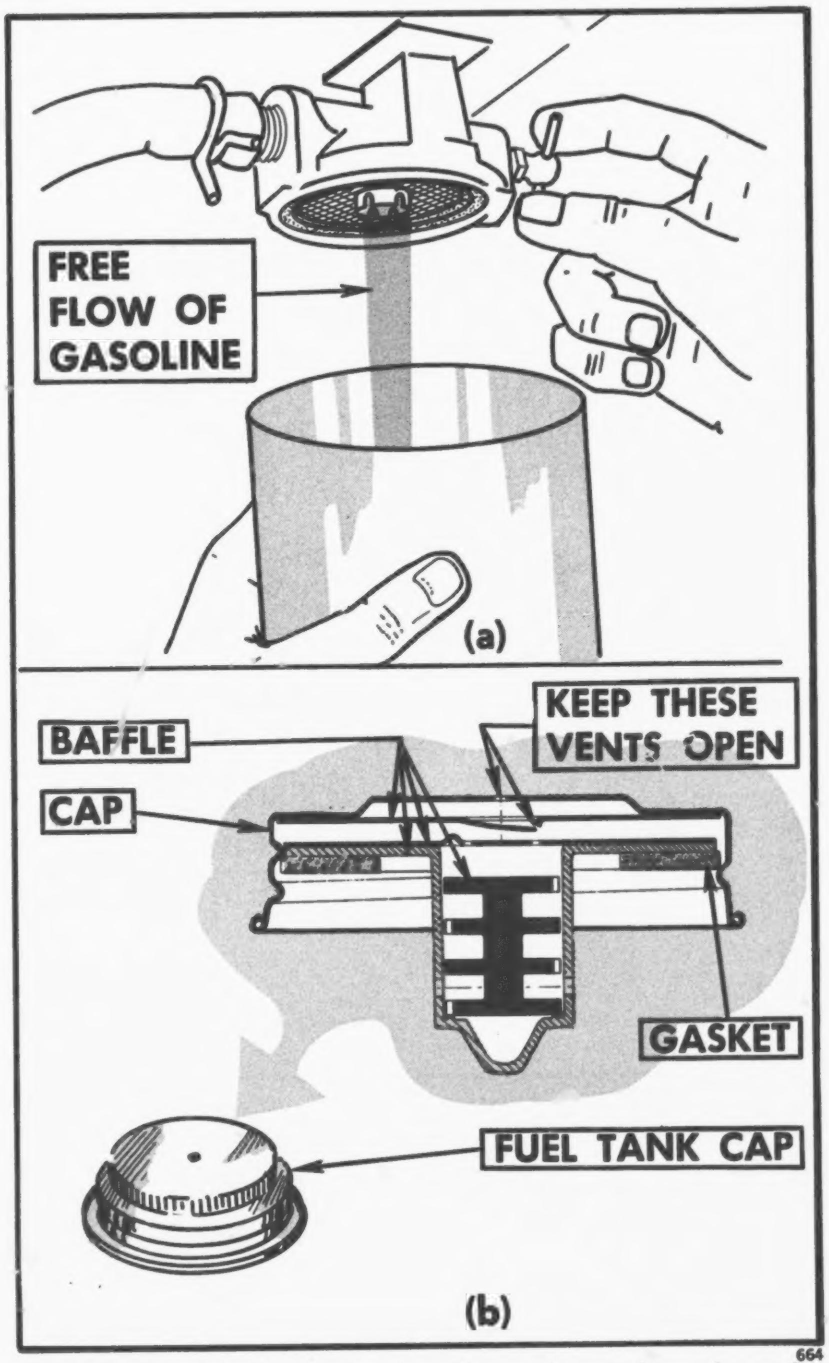


FIGURE 50. (a) Check for free-flow of gasoline through the shut-off valve. (b) A fuel-tank cap must be vented in order to allow atmospheric pressure into the fuel tank so fuel will flow readily. (Inset) Cutaway of one type of vented fuel-tank cap with plunger. The plunger prevents spilling of gasoline.

8. *Clean and then dry sediment bowl.*

   After cleaning, wipe bowl dry so that no lint is left in the bowl.

9. *Open fuel valve and drain out approximately a cup of fuel (Figure 50).*

   CAUTION! Collect fuel in a can to avoid a fire hazard.

   This procedure removes any dirt lodged between the tank and the strainer. It will also serve as a check on the condition of the vent in the fuel tank cap. *If the vent hole is clogged,* the flow will be slow. Remove the tank cap and open the vent hole with cleaning solvent. A clogged vent will restrict the fuel flow so that the engine will not run properly, or it will stop completely.

10. *Install gasket, strainer, and sediment bowl (Figure 51).*

    Use a new gasket if needed.

    If you do not have a new gasket and if the old one is still in good condition, note which side was next to the bowl; then turn it over so the opposite side will contact the bowl when you put it back in place. This provides new surface contacts and a better seal.

    If the **gasket is cracked or damaged,** be sure to replace it with a new gasket. A damaged gasket will likely leak.

11. *Fill the sediment bowl before tightening the jam nut.*

    This will allow air to escape and helps avoid possible air lock in your fuel line.

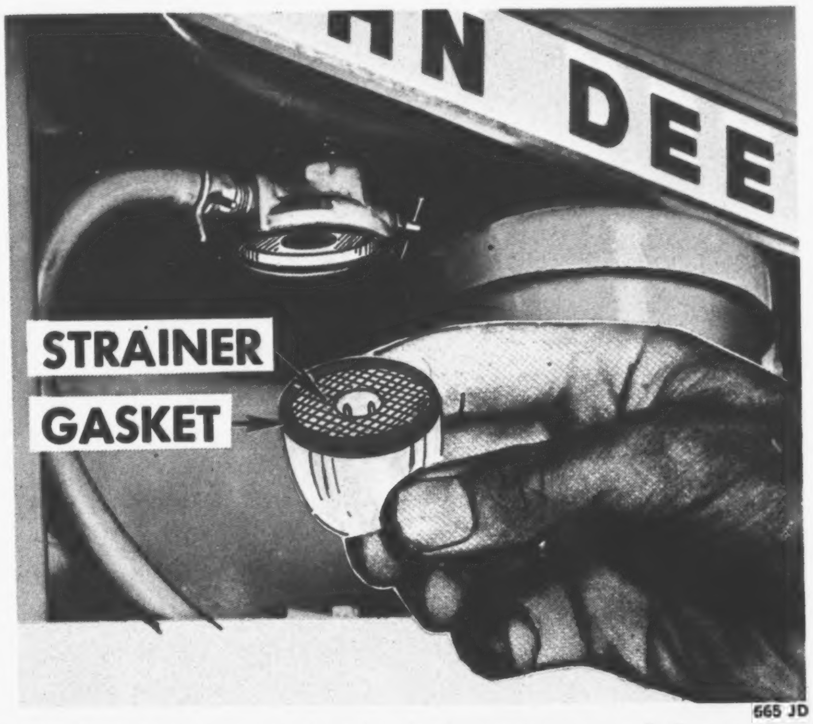


FIGURE 51. Be sure that both the strainer and the gasket are centered over the bowl when installing.

12. *Tighten bowl against gasket with jam nut.*

13. *Check for leaks before operating the engine.*

14. *Reconnect spark-plug wire to spark plug.*

15. *Operate engine for a few minutes and re-check for leaks.*

SERVICING THE SCREEN-TYPE OF FUEL STRAINER

Engines without sediment-bowl-type fuel strainers depend on **wire mesh** or **fiber** strainers in the fuel tank to filter foreign particles from the gasoline (Figure 46b and c). To service a screen-type strainer, proceed as follows:

1. *Disconnect the spark-plug wire.*

   This prevents the engine from starting accidentally.

2. *Close fuel shut-off valve (if one is installed).*

3. *Remove fuel line from fuel tank (Figure 52).*

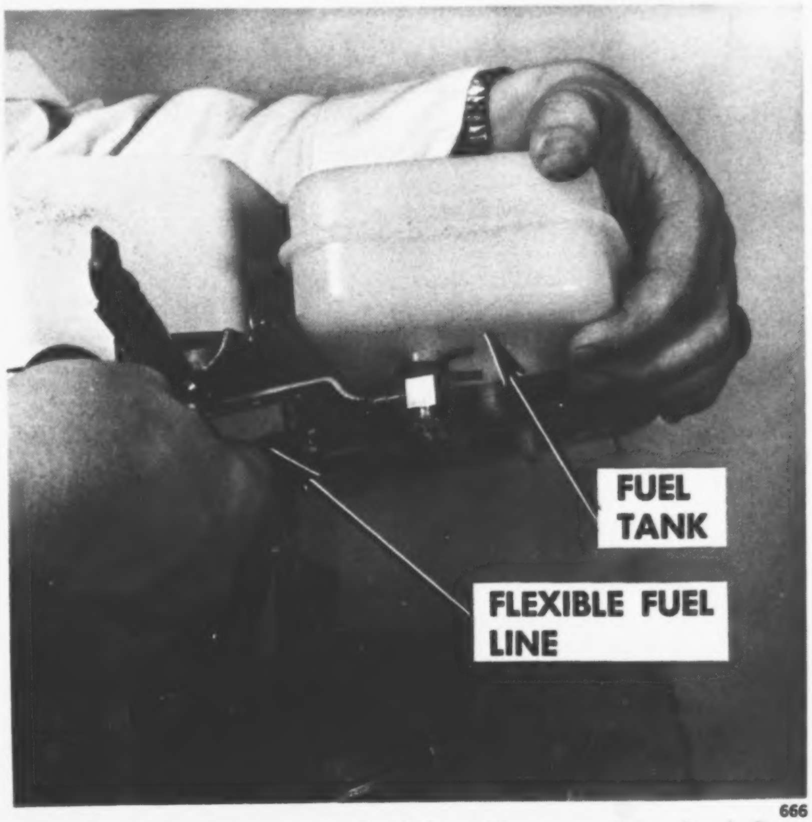


FIGURE 52. Removing fuel by disconnecting fuel line from fuel tank, if there is no shut-off valve.

   If you have no fuel shut-off valve, drain the fuel tank by disconnecting the fuel line and/or removing the fuel tank, or by removing the filler cap and tipping the engine until the fuel drains through the filler hole.

4. *Remove fuel shut-off valve and/or fuel strainer from fuel tank if possible.*

   On most engines this step is done by unscrewing the fuel shut-off valve or the tank fitting on which the screen is mounted. Take care not to damage the screen while removing it (Figure 46b).

   If the engine has a **flexible hose and strainer** (Figure 46c) and the strainer is inside the fuel tank, fish it out with a wire hook.

   Some engines have **strainers built into a plastic fuel tank.** If yours is built into the fuel tank, remove the tank from the engine and clean the tank and strainer without removing the strainer.

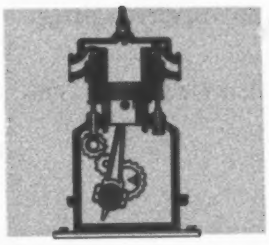
5. *Clean fuel strainer.*

   Swish the fuel strainer in clean solvent and dry with compressed air, if it is available.

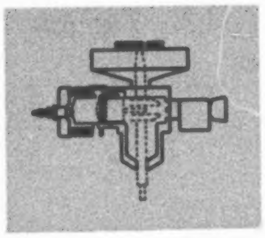
6. *Replace fuel-strainer assembly in reverse order of removal.*

   When re-installing fuel hose, check for cracks and signs of deterioration. If they are present, replace the fuel line.

7. *Re-connect spark-plug wire to spark plug.*



E. SERVICING CRANKCASE BREATHERS



Four-cycle engines have a "breather vent" in the crankcase.

Crankcase breathers serve four purposes:

- Avoid a build-up of excessive pressure in the crankcase.
- Allow for removal of harmful gases and vapors from the crankcase.
- Maintain a partial vacuum — or a slight pressure — in the crankcase.
- Keep out dust and dirt.

Two-cycle engine crankcases are not vented because the fuel and oil enter the combustion chamber through the crankcase. Consequently, the crankcase is sealed and operates under pressure.

Crankcase breathers should be cleaned at least once each year. Servicing the breather consists of cleaning the filter element and checking the breather valve for proper operation.

The types of crankcase breathers used on **4-cycle engines,** how they work, and how to service them are discussed under the following headings:

1. Types of crankcase breathers and how they work.
2. Importance of proper servicing.
3. Tools and materials needed.
4. Cleaning the crankcase breather.

TYPES OF CRANKCASE BREATHERS AND HOW THEY WORK

The breather is usually located in the valve-tappet access well (Figure 53a) or in the valve-tappet access-well cover.

How does the crankcase breather **prevent excessive pressure build-up** in the crankcase? During combustion a certain amount of "blow-by"** from the combustion chamber passes by the piston rings into the crankcase. If your engine had no breather, this pressure would build up to the point where oil seals and gaskets would be ruptured and oil leaks would result. Consequently, if the breather does not operate properly, or if it becomes clogged, the results are the same as they would be with the engine having no breather. *The crankcase breather valve relieves the excessive pressure* by providing an outlet for air to escape when the pressure in the crankcase becomes greater than that of outside atmospheric pressure (Figure 53a).

---

*After studying this section you will be able to determine which type breather is on your engine and to enter the information in your inventory form shown in the Appendix, page 145.

**"Blow-by" is the term used to describe gasses under pressure leaking by the piston rings during combustion and the power stroke.

Harmful gases and vapors are removed from the crankcase by the same action. These gases and vapors get into the crankcase as a result of blow-by past the piston. If not removed, they use up the additives in the oil and cause it to oxidize. This in turn causes corrosion of engine parts and loss of lubricating qualities in the oil.

On some 4-cycle engines the breather provides **a partial vacuum or a slight pressure** in the crankcase (Figure 53). The valve allows the gases to escape from the crankcase, but a lesser amount of air is allowed to enter. This process is done by two different methods: (1) some valves are designed so as not to close completely, and (2) some close but have a small opening in the valve to allow some air to enter. As a result, a partial vacuum (from 0.5 to 1.0 inch of Mercury) or only a slight pressure is maintained in the crankcase. (1″ of Hg = .5 pounds per square inch.) This low or negative pressure helps prevent oil leaks through the oil seals and gaskets.

There are *three types of valves* used in crankcase breathers: (1) reed type, (2) ball check type, and (3) floating disk type.

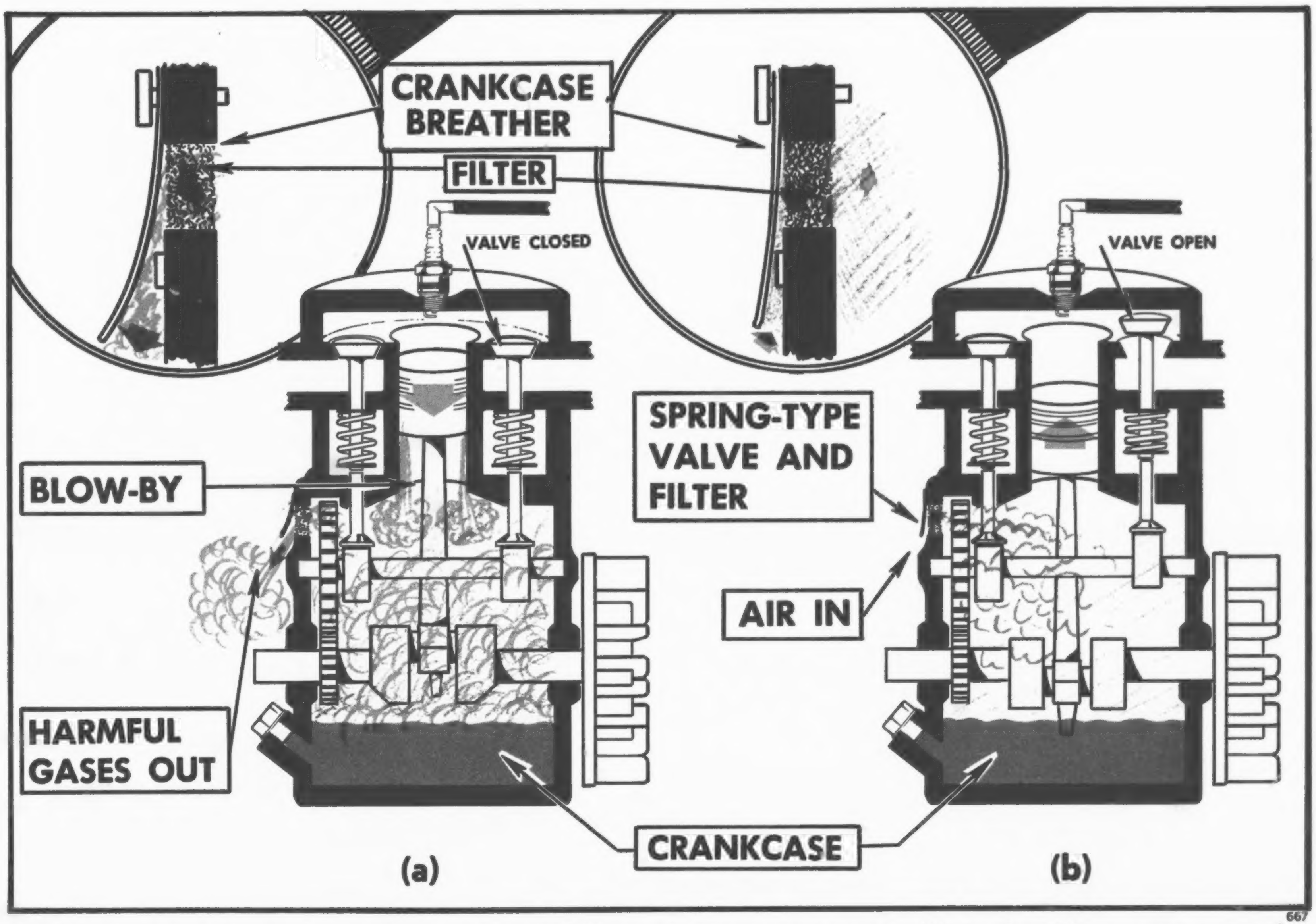


FIGURE 53. Principles of the crankcase valve and filter. (a) As the piston moves down, pressure builds up in the crankcase. This pressure is a result of both the downward motion of the piston and the "blow-by." The valve in the crankcase breather opens and allows air to escape. This reduces the pressure and gets rid of harmful gases and vapors. (b) As the piston moves upward, pressure is reduced in the crankcase. The valve in the crankcase breather closes, thus allowing little or no air to enter. This closure maintains a partial vacuum or slight pressure in the crankcase.

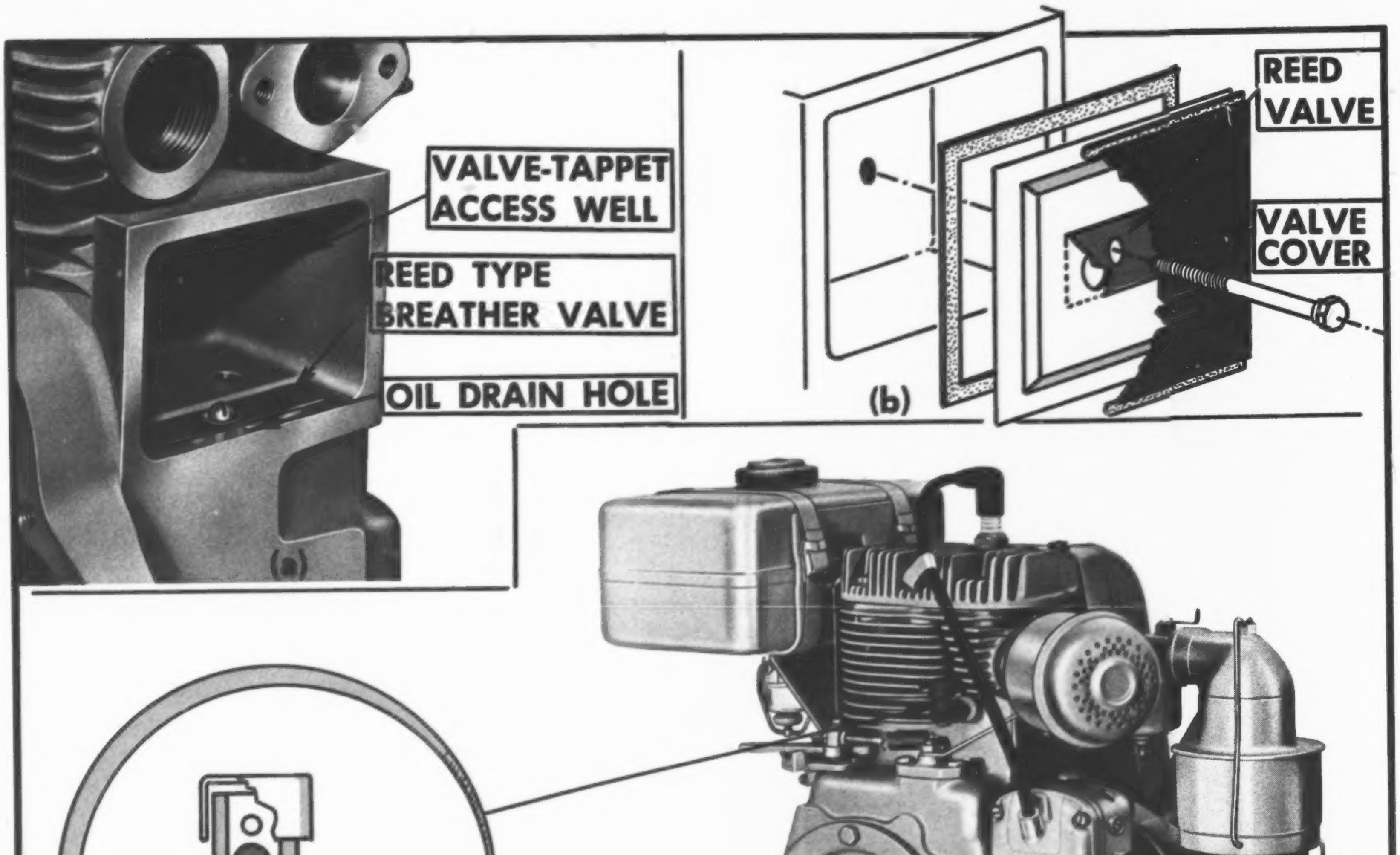


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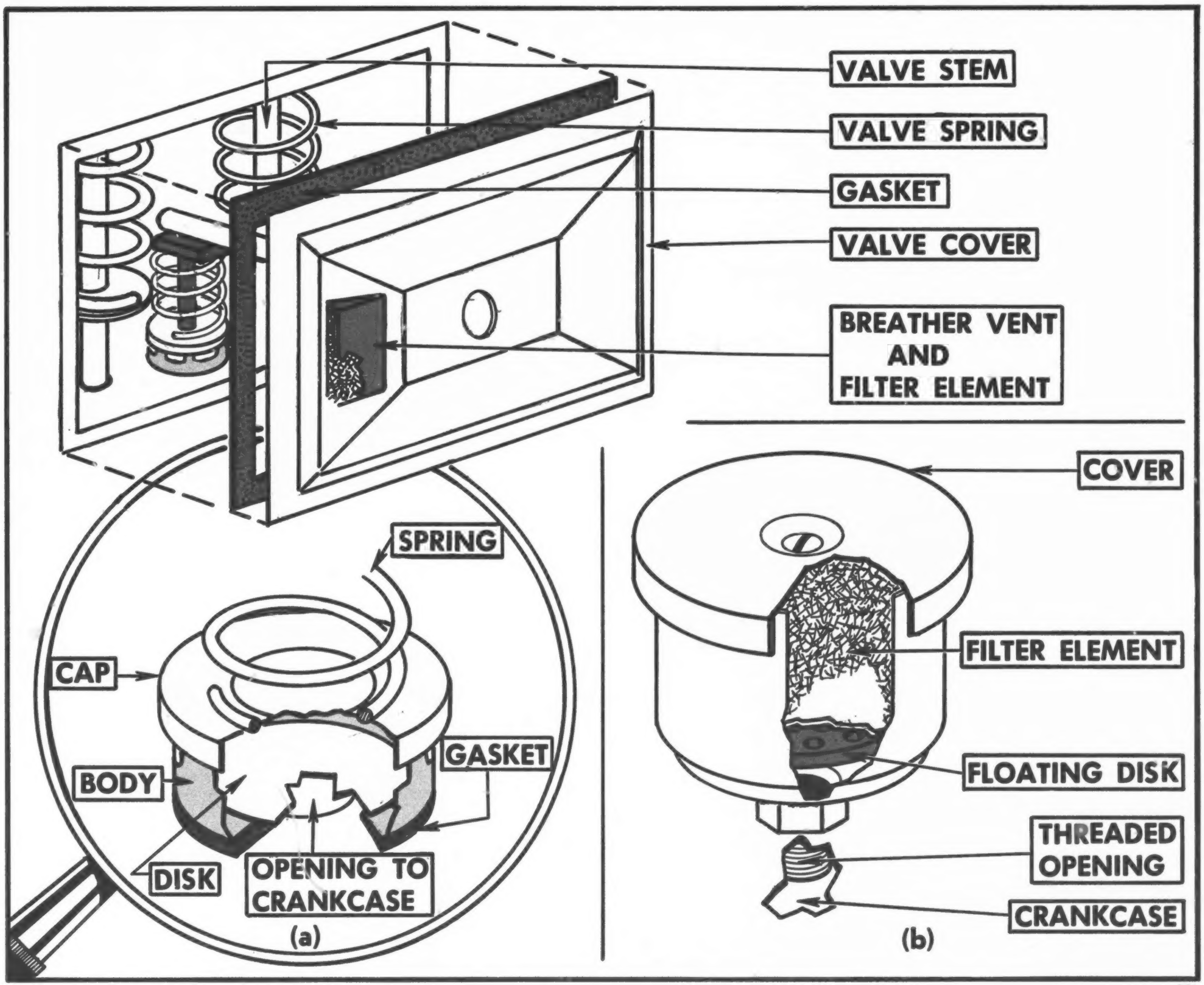
FIGURE 54. (a) A crankcase-breather reed valve located in the valve-tappet access well. (b) A crankcase-breather reed valve located in the valve-tappet access-well cover. (c) A ball check breather valve located outside the crankcase.

The metal **reed valve** (Figure 54a and b) is opened by pressure in the crankcase, and it is partially closed by spring tension. (Neither valve closes completely.) This action controls the amount of air that enters the crankcase.

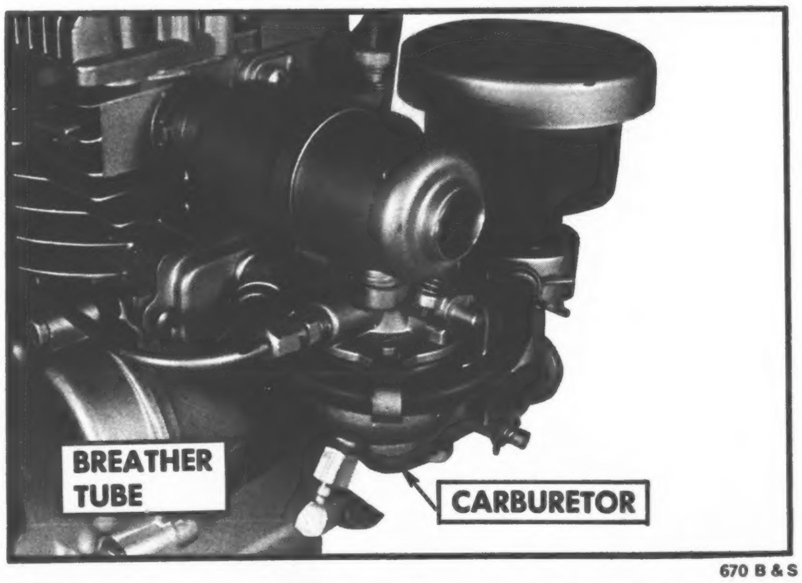
The steel **ball-check** (Figure 54c) and **floating-disk valves** float freely. They are opened by pressure in the crankcase, and partially closed by gravity or atmospheric pressure.

Air from the crankcase may be vented either to the outside air or to the carburetor (Figure 56). If the breather is vented to the atmosphere, a filter is necessary (Figures 55 and 57). Its job is to remove dust and dirt from the air entering the crankcase. It is a part of the crankcase breather. Filters are made of metal maze, animal hair, or polyurethane.


VALVE STEM
VALVE SPRING
GASKET
VALVE COVER
BREATHER VENT AND FILTER ELEMENT
SPRING
CAP
BODY
GASKET
DISK
OPENING TO CRANKCASE
(a)
COVER
FILTER ELEMENT
FLOATING DISK
THREADED OPENING
CRANKCASE
(b)

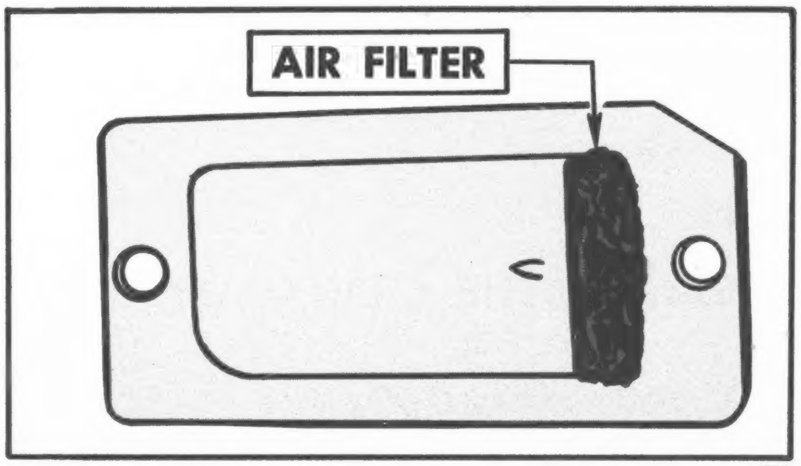
669

FIGURE 55. (a) A crankcase breather with a floating disk valve in the access well. (b) A combination crankcase breather valve and filter designed for mounting on the crankcase housing.


BREATHER TUBE
CARBURETOR

670 B & S

FIGURE 56. A crankcase breather vented to the carburetor intake.



671

FIGURE 57. The air-cleaning filter on a crankcase breather may be made of metal maze, animal hair or polyurethane.

IMPORTANCE OF PROPER SERVICING

From the foregoing discussion of how breathers work, you can see what will happen *if the breather becomes clogged.* Excessive pressure, or vacuum, builds up in the crankcase; oil seals and gaskets become ruptured; and oil leaks develop (Figure 58). Failure to clean the filter regularly may cause this condition.

If the inlet passage becomes clogged, air can get out but not in. Too much negative pressure (vacuum) will develop and dirt will be drawn in through the oil seals. Gaskets will have a tendency to be drawn into the engine.

If oil leaks out through the breather, it is a good sign of a clogged breather valve, or worn or damaged parts. It may be an indication, however, of improper breather assembly, engine running too fast, operating the engine at too much of an angle, worn piston rings, or breather installed up-side-down.

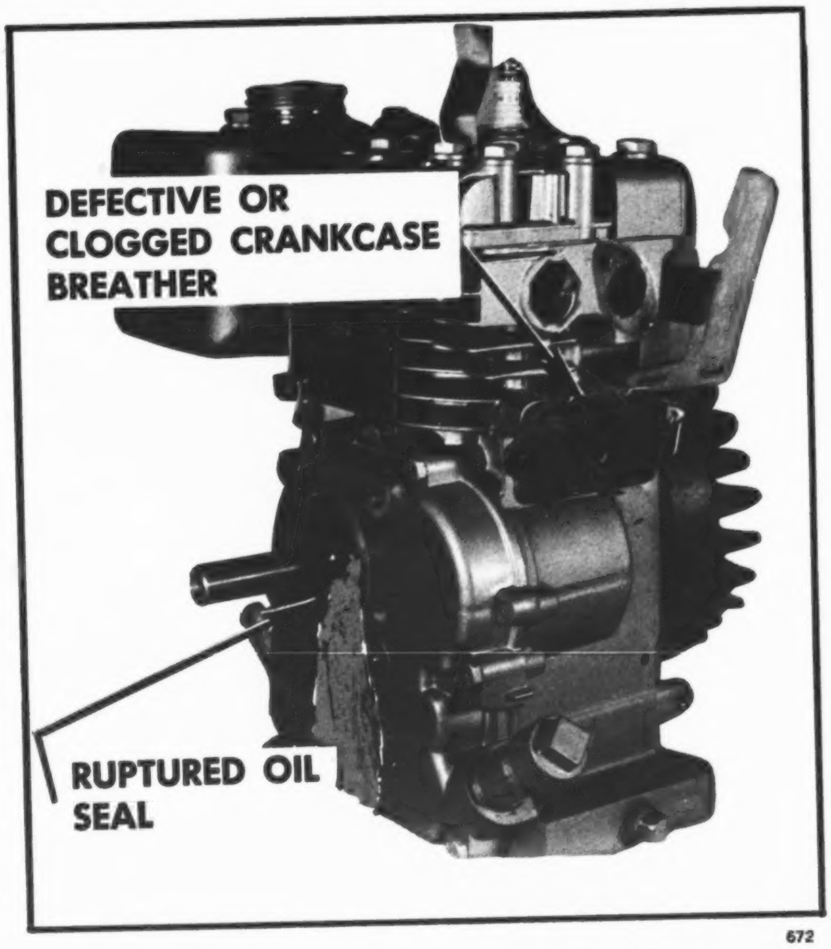


FIGURE 58. Crankcase breathers when working properly prevent an excessive build-up of pressure in the crankcase that would rupture gaskets and oil seals.

TOOLS AND MATERIALS NEEDED

1. Open-end wrenches — 7/16" and ½"
2. Slot-head screwdriver, 8"
3. Combination pliers — 7"
4. Clean rags
5. Petroleum solvent (mineral spirits, kerosene, or diesel fuel)
6. Container for cleaning parts.
7. New gasket

CLEANING THE CRANKCASE BREATHER

1. *Disconnect spark-plug wire.*
2. *Check breather for proper operation.*

   Unusual oil leaks anywhere on the crankcase may be a sign of a clogged breather.

   It is possible to check breathers which are vented to the carburetor by removing the hose and placing your finger over the breather opening. You can feel the pressure and suction.

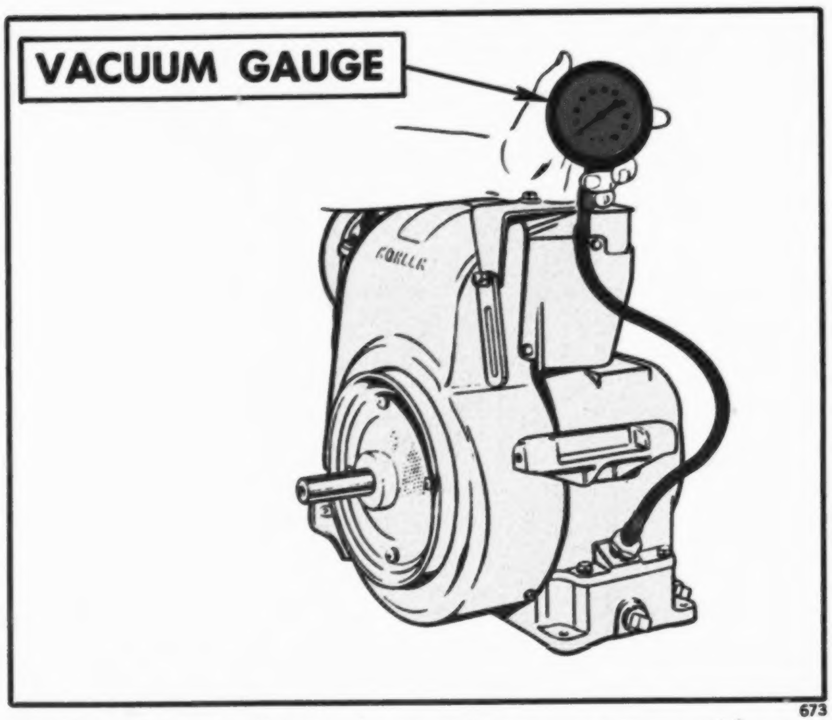


FIGURE 59. Checking the crankcase vacuum with a vacuum gage.

It can be measured with a vacuum gage, U-tube manometer, or a pressure gage — depending on the specification for your engine. Few manufacturers, however, publish the pressure at which the crankcase should operate.

If the engine crankcase is designed to operate on a negative (vacuum) pressure, connect a vacuum gage to the crankcase by inserting a tube and cork in the oil-filler hole (Figure 59) and then operating the engine. The vacuum gage should register approximately 0.5 to 1.0 inches of mercury (1″ of Hg. = .5 pounds per square inch).

3. *Remove crankcase breather cover, if installed.*

If there is a breather tube, as shown in Figure 56, release hose clamp and remove it with a twist and a pull.

The valve cover may be held by a stud bolt and nut, or by capscrews. It may be necessary to remove the carburetor or some other accessory to get to the breather. If so, refer to the procedures in Volume II, that apply to that accessory.

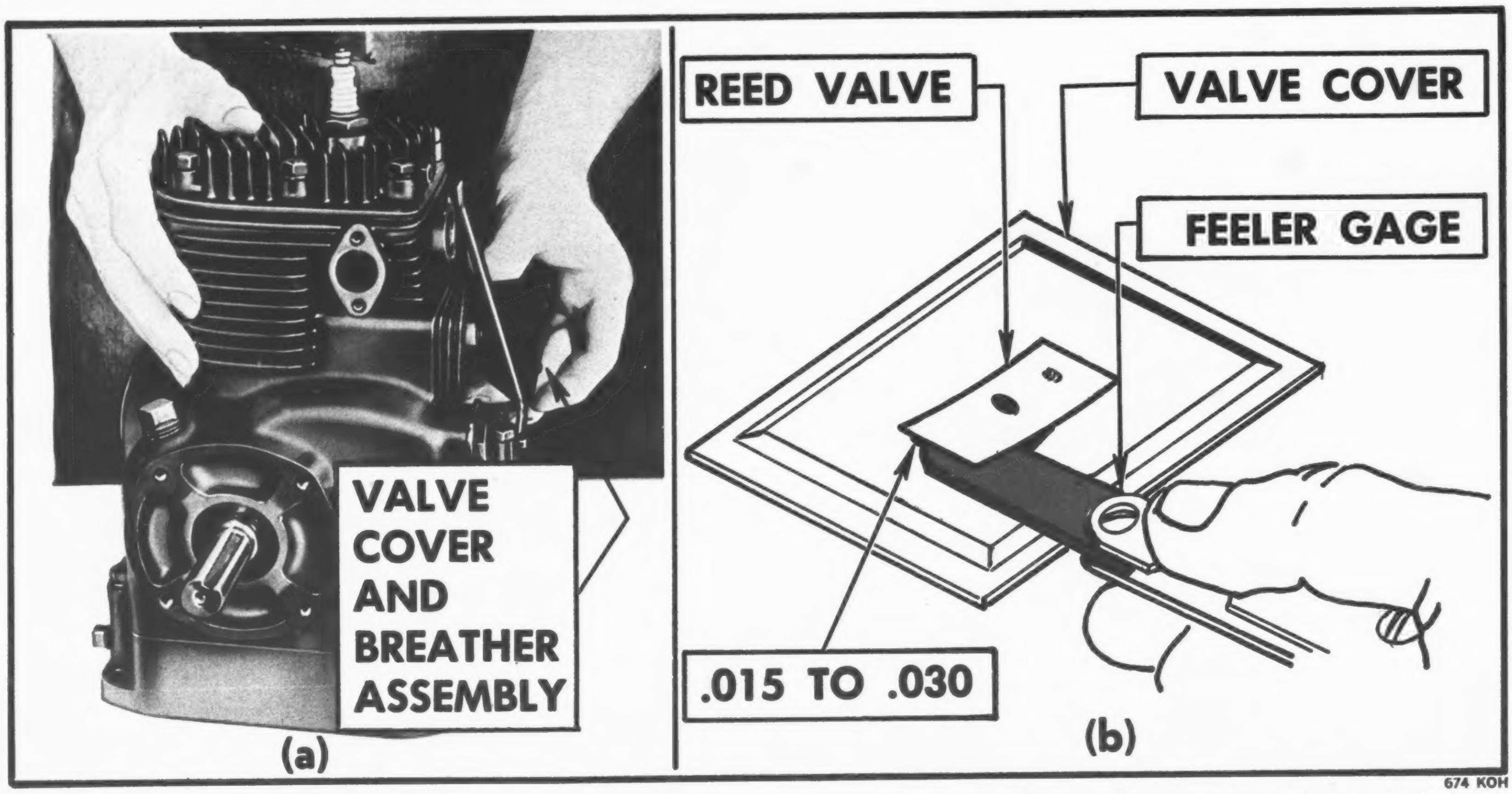


FIGURE 60. (a) Removing valve cover plate and crankcase-breather assembly. (b) Checking the reed clearance.

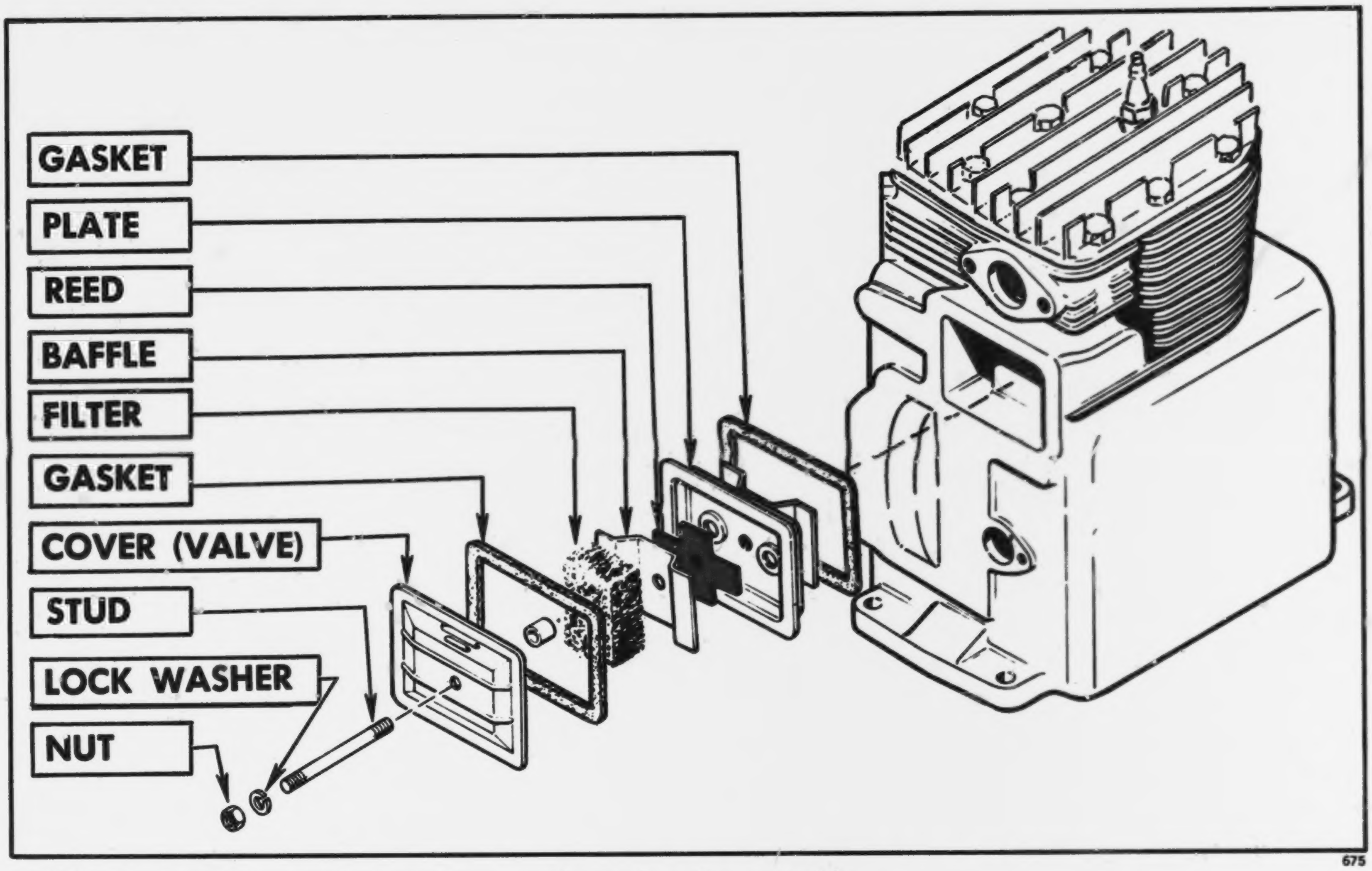


FIGURE 61. Parts of a typical reed-type crankcase breather assembly.

4. *Remove the crankcase breather, if it is not a part of the cover.*

   The breather may be located in the valve cover or valve-tappet access well.

5. *Check breather valve for clearance.*

   Valves should never close completely.

   Check **reed valves** with a feeler gage (Figure 60b). Clearance should be .015" to .030".

   Check floating **disk valves** for freedom of action and some clearance. No specific clearance is given because it is difficult to measure. Also, it is not likely to change because of the construction of the valve.

   If the breather needs cleaning, proceed to step 6.

6. *Disassemble crankcase breather (Figure 61).*

   Be sure to remember the order in which the breather is assembled. Make a sketch if necessary.

7. *Clean parts in petroleum solvent.*

   Refer to "Servicing Carburetor Air Cleaners," page 32, for directions for cleaning the filter element.

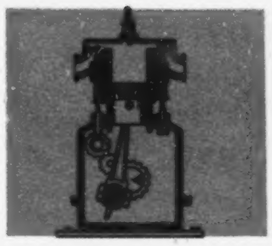
   Allow the parts to dry.

8. *Reassemble and install breather.*

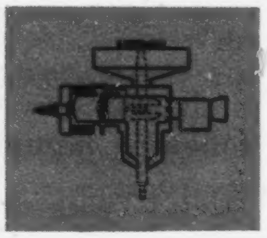
   Be sure to reassemble breather in proper order. If you are not certain, refer to your original sketch.

   Some breathers have **oil drain holes.** If yours does, install the breather with the drain hole toward the base of the engine. Failure to do this will cause oil to be pumped out through the breather.

   Replace all gaskets with new ones. Old gaskets will not provide a good seal.



F. LUBRICATING SMALL ENGINES



Manufacturers are concerned with the number of early engine failures which occur as a result of their engines being operated with *not enough oil* or with the *wrong kinds of oil.* They go to great lengths to try to impress you with the need for proper engine lubrication.

Oil is necessary for the operation of your engine. Without lubrication the pistons would seize and bearings would burn out. The better the lubrication, the more power you will get. Engine life also depends upon how well the engine is lubricated.

The reasons are as follows:

- *Oil reduces friction between moving parts (Figure 62).*

  It provides a cushion between moving parts and keeps them apart. This cushion helps prevent scoring and fusing of metal caused by heat and abrasion.

- *Oil reduces heat by reducing friction.*
- *Oil cleans.*

  Much of the dirt is suspended in the oil and is removed with each oil change (4-cycle engines).

  Special detergents are added to most oils for this purpose.

- *Oil prevents corrosion.*

  Some oils have special rust inhibitors for this purpose.

- *Oil helps seal piston rings to help prevent blow-by.*
- *Oil helps increase power output by reducing friction.*

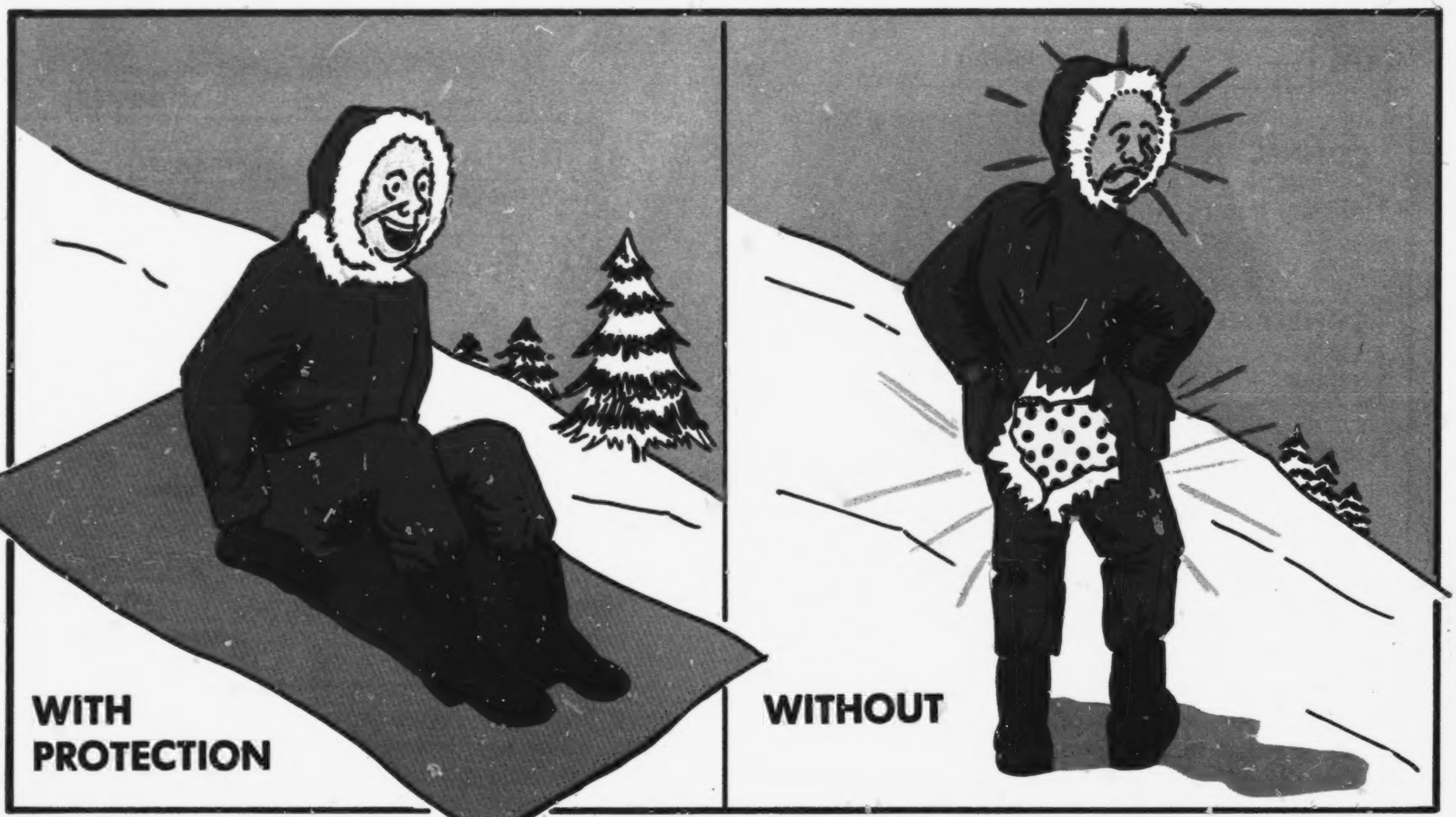
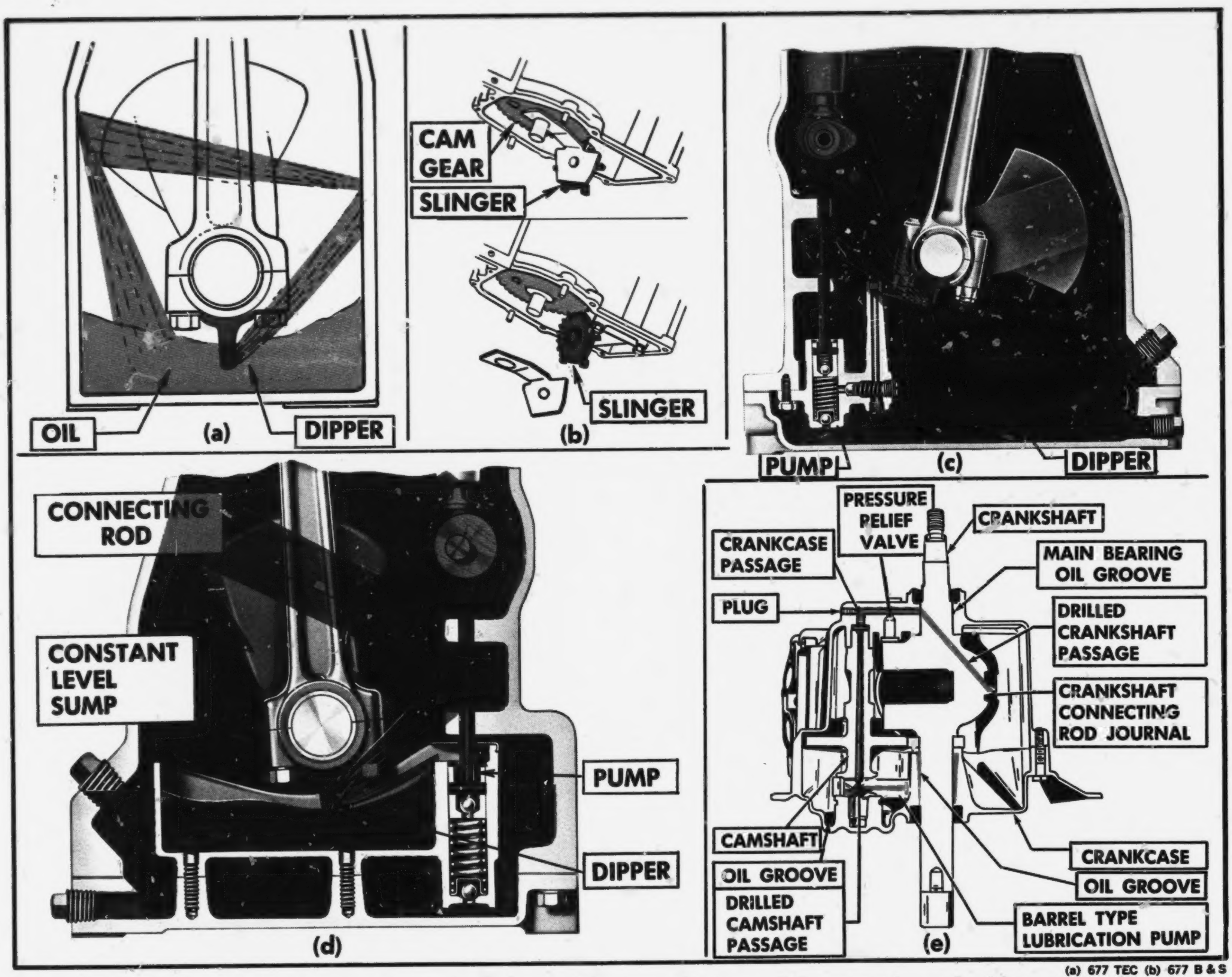


FIGURE 62. Friction causes wear between moving parts.

The importance of lubricating your engine properly and how to do it are discussed under the following headings:

1. Types of lubrication systems and how they work.
2. Importance of proper lubrication.
3. Selecting the crankcase oil.
4. Tools and materials needed.
5. Checking the crankcase oil level (4-cycle engines).
6. Changing the crankcase oil (4-cycle engines).
7. Storing the crankcase oil.

TYPES OF LUBRICATION SYSTEMS AND HOW THEY WORK


OIL
(a)
DIPPER
CAM GEAR
SLINGER
SLINGER
(b)
PUMP
(c)
DIPPER
CONNECTING ROD
CONSTANT LEVEL SUMP
PUMP
DIPPER
(d)
PRESSURE RELIEF VALVE
CRANKSHAFT
CRANKCASE PASSAGE
MAIN BEARING OIL GROOVE
PLUG
DRILLED CRANKSHAFT PASSAGE
CRANKSHAFT CONNECTING ROD JOURNAL
CAMSHAFT
OIL GROOVE
DRILLED CAMSHAFT PASSAGE
CRANKCASE
OIL GROOVE
BARREL TYPE LUBRICATION PUMP
(e)

(a) 677 TEC (b) 677 B & S

FIGURE 63. Types of 4-cycle engine oil systems. (a) Dipper attached to the connecting rod journal picks up oil from the oil sump and splashes it about in the crankcase. (b) Oil slingers driven by cam gears. They pick up oil from the oil reservoir—as does the dipper—and splash it over the crankcase. (c and d) Oil pumps used to pick up oil from the reservoir and either spray it onto a dipper or empty it into a constant-level sump. (e) A positive-pressure type lubrication system. Oil is supplied by a pump and delivered through drilled passageways directly to the bearing surfaces.

The lubrication systems for 4-cycle and 2-cycle engines are entirely different. Figure 7 illustrates the basic differences.

All **4-cycle engines** are *lubricated from an oil reservoir.* There are, however, variations in the methods by which the oil gets to the bearing surfaces. Four common methods are illustrated in Figure 63.

They are as follows:

- *Dipper and sump* (Figure 63a) — As the crankshaft turns, oil is picked up from the sump by a dipper attached to the rod bearing cap, and it is splashed about inside the crankcase.
- *Slinger* (Figure 63b) — Oil is picked up from the oil sump by a rotating slinger, and it is splashed about inside the crankcase. The slinger is driven by the cam gear.
- *Pump and dipper* — Oil is pumped from the oil sump and sprayed onto a dipper; then it is splashed about inside the crankcase (Figure 63c). Or oil is pumped into a constant level sump. Then it is picked up by a dipper and splashed about inside the crankcase (Figure 63d).
- *Pump and pressure system* (Figure 63e) — Oil is pumped from the oil sump through drilled passageways to the bearings. The pressure is kept constant by a relief valve.

Larger multi-cylinder engines have crankcase lubrication systems similar to those in the small 4-cycle engines discussed here.

Small **2-cycle engines** are *lubricated by oil in the fuel.* The mixture passes through the crankcase (Figure 64). (See Figure 6 for the principles of operation.)

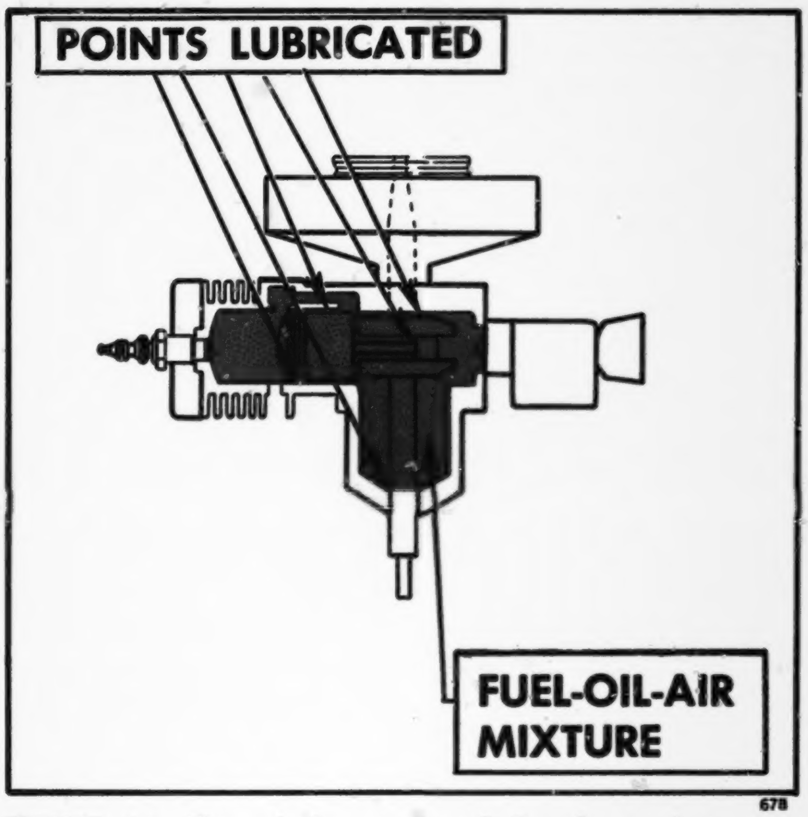


FIGURE 64. The moving parts of 2-cycle engines are lubricated by small droplets of oil suspended in the fuel.

The oil and fuel are momentarily pressurized in the crankcase when the piston moves toward the crankshaft. This event causes some of the oil to condense on the bearing surfaces.

As the piston moves upward, oil condenses from the mixture in the combustion chamber to lubricate the piston, rings, and cylinder walls. The remainder is burned during combustion.

Mixing oil and gasoline for 2-cycle engines is discussed under "Refueling Small Engines," page 68.

IMPORTANCE OF PROPER LUBRICATION

You cannot afford to neglect the lubrication of a small engine. Of course no engine, regardless of size, should be neglected. But small engines are not so well protected as large engines (Figure 65); therefore, your lubrication procedures become more important.

Some of the many reasons why you should see that your small engine is lubricated properly are as follows:

- *Few small gasoline engines have an oil filter.* Therefore, the oil should be changed frequently to remove metal particles, dirt, and sludge that a filter would remove.

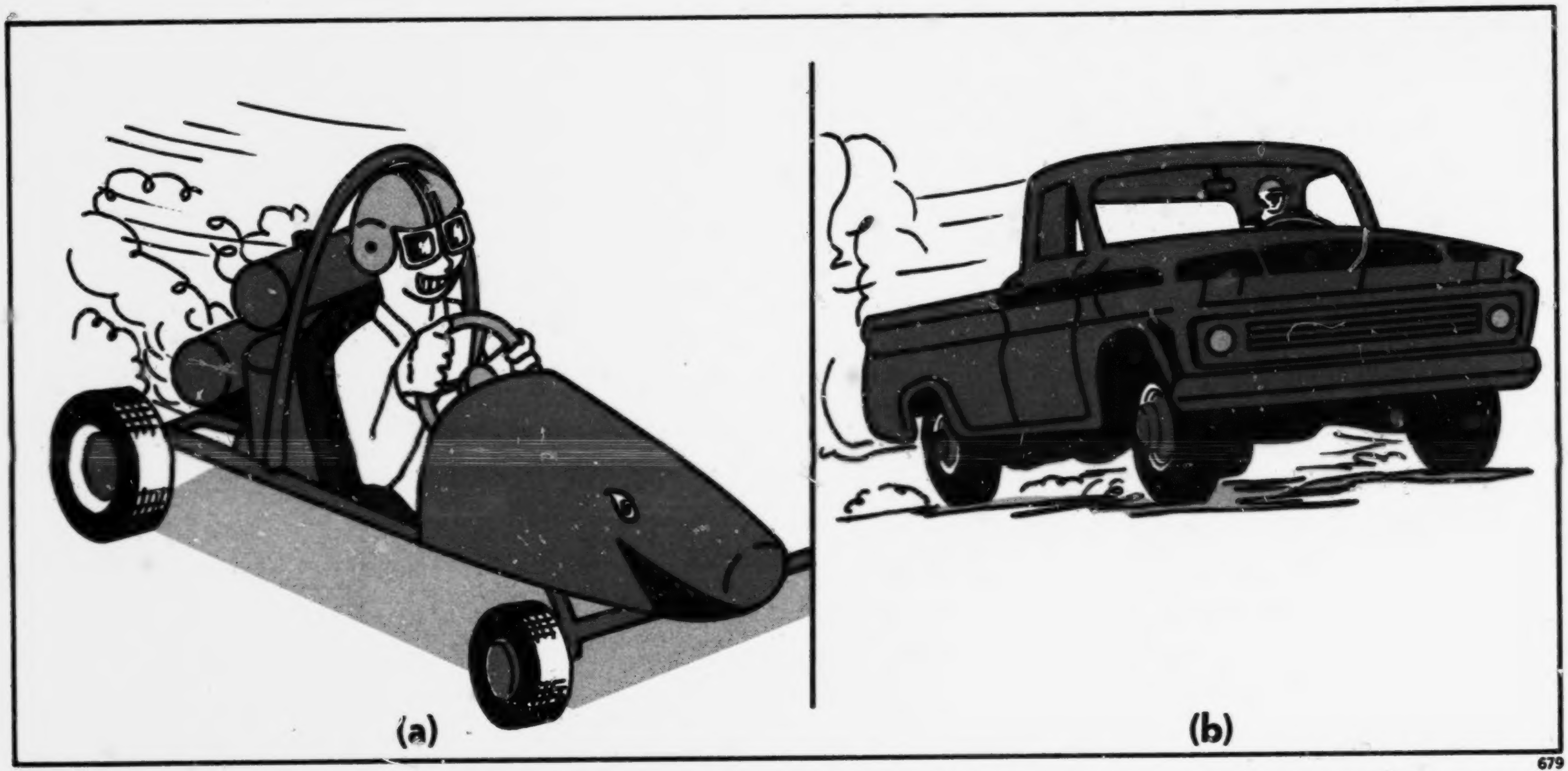


FIGURE 65. Small engines are not usually so well protected as large engines. (a) Many applications for small engines are near the ground where dust is thickest. (b) Automotive engines are usually somewhat removed from intense dust.

- *The oil in air-cooled engines runs hotter than oil in water-cooled automobile engines.* This high temperature causes the oil to oxidize and break down if it is not drained at regular intervals.
- *Most small engines operate near the ground;* therefore, dirt and dust are more likely to get into the crankcase.
- *Most small engines have no oil-pressure gage or warning light* to show when the pressure is low.
- *The amount of oil available in small engines is relatively small.*
- *Small engines usually operate at maximum power output.* Extreme pressures between moving parts tend to squeeze the oil out from between the bearing surfaces.
- *Small engines are lightweight* and may vibrate more than large engines. Vibration adds to the bearing load.
- *Few small engines are given a warm-up period before a load is applied.*
- *Most small engines are used for intermittent service.*

Figure 66 shows the rate at which frequent starting and short running time increased cylinder wear during one experiment.

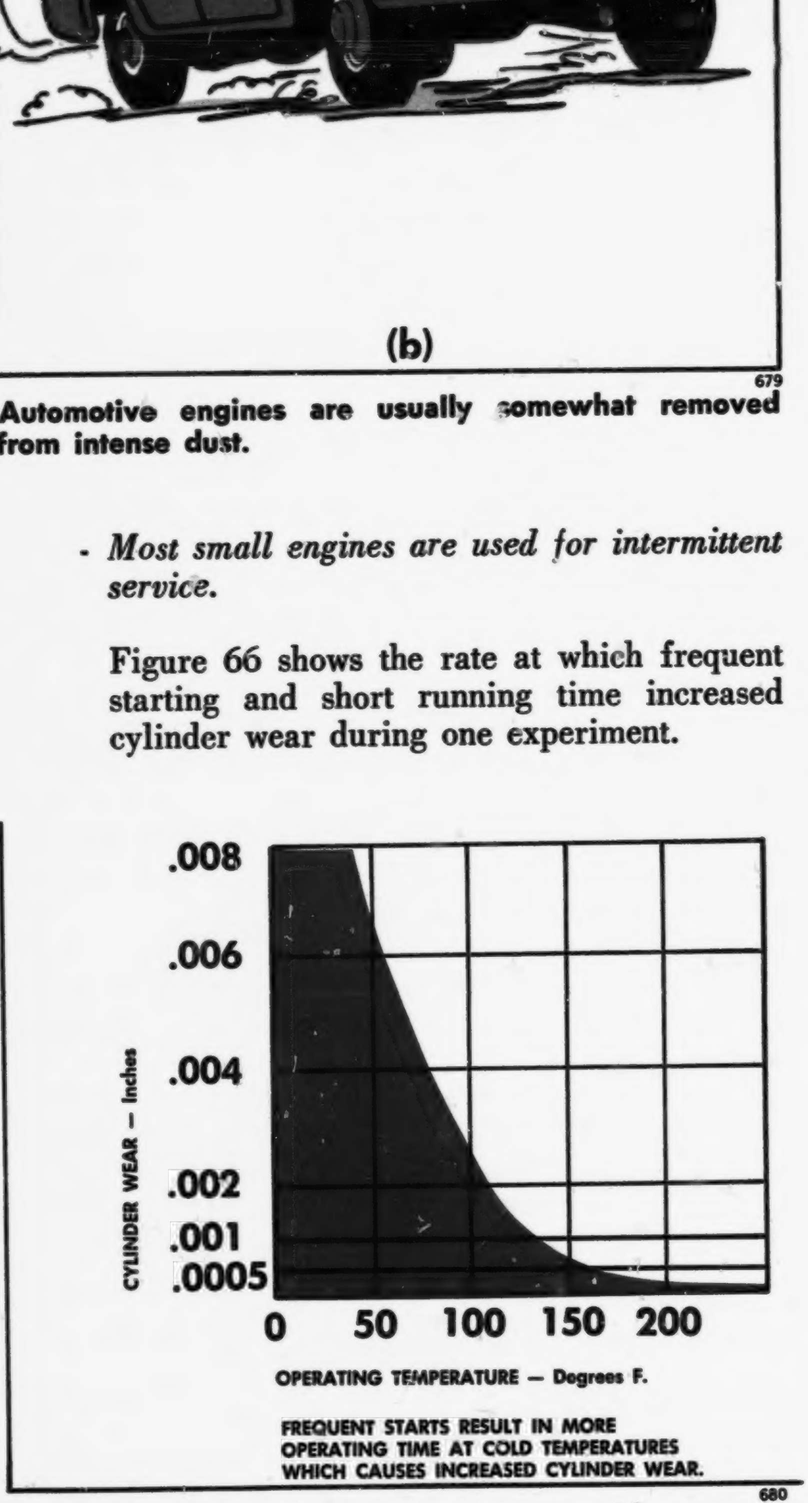


FIGURE 66. How cylinder wear increases with numerous starts and short runs.

More wear is expected of an engine that operates for short intervals than of one that is operated for long periods of time.

This is primarily because of cold starts. The proper oil film cannot be established on the various rubbing surfaces until the oil has warmed up and become sufficiently fluid.

Oil may not reach the piston rings until after the engine has turned over several times. This lack of lubrication can cause two conditions: (1) rapid wear of the piston rings and cylinder walls, and (2) failure of the rings to seal off compression. Blow-by is increased. Blow-by sends harmful chemicals by the piston rings to the crankcase.

During choking, raw gasoline in the combustion chamber washes down the cylinder walls and worsens the conditions described in the previous paragraph. As this continues, *oil in the crankcase is diluted* and loses its effectiveness. After the engine warms, however, the gasoline is evaporated by heat.

You might think from the foregoing information that your small engine is doomed to failure, but this is not true. *If you service your engine properly and keep it lubricated* according to the manufacturer's recommendations, it will give you long and satisfactory service.

In view of the numerous opportunities the oil has of becoming contaminated with raw fuel, dirt, and oxidation products in small engines, it should be drained as often as recommended by the manufacturer.

SELECTING CRANKCASE OIL

The cost of oil is the smallest of your operating expenses. Selecting the proper oil, however, is one of the most important decisions you make for your engine. The wrong type of oil may cause the piston in your engine to look like the one in Figure 67a.

The proper oil for lubricating your small engine may be described on the *engine nameplate,* in the *operator's manual,* or in *lubrication guides* produced by major oil manufacturers. Specifications will be given in two ratings: (1) API (American Petroleum

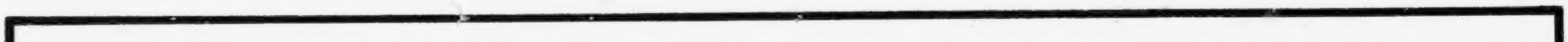


FIGURE 67. (a) Results of using improper oil. (b) A piston from an engine which had the proper oil.

Institute) Service classification — often called "type" of oil, and (2) SAE Viscosity — often called "viscosity grade."*

All 4-cycle engines require a good **type of oil** — such as MS (API Classification). MS oil is developed for engines operating under severe conditions such as numerous starts and stops, high temperatures and maximum loads and/or speeds. Table I describes the different A.P.I. classifications.

TABLE I.

A. P. I. CRANKCASE OIL SERVICE CLASSIFICATIONS (1952 to date)

API Service Classifications	Service Conditions
ML (Motor Light)	Service typical of **gasoline and other spark-ignition engines** used under light and favorable operating conditions, the engines having no special lubrication requirements.
MM (Motor Moderate)	Service typical of **gasoline and other spark-ignition engines** used under moderate to severe operating conditions, but presenting problems of deposit or bearing-corrosion control when crankcase oil temperatures are high.
MS (Motor Severe)	Service typical of **gasoline and other spark-ignition engines** used under unfavorable, or severe, types of operating conditions, and where there are special lubrication requirements for deposits, wear, or bearing corrosion control.

Oils with additives are recommended for most **4-cycle engines.** (MS oils have additives.) Additives are chemicals put in the oil by the oil manufacturer to improve the quality of the oil. Some *additives help prevent corrosion; some provide a better cushion between the moving parts; and some help prevent scuffing and reduce wear.*

Detergent-dispersants are additives commonly called "detergents." *Detergents* in the oil help pick up dirt and sludge, and suspend them in the oil.

NOTE: Never add special oil treatments to your engine. If you use the proper oil, there is little good that they can do; and some can be harmful to your engine.

Manufacturers of **2-cycle engines** generally recommend oils with **special additives.** Here is the reason. Since 2-cycle engines are lubricated by mixing oil with the fuel, it means that the oil enters the cylinder and is subject to burning with the fuel. The additives in some regular crankcase oils do not burn completely. They sometimes leave a residue that fouls the spark plugs and clogs the exhaust ports. The special additives are selected to avoid this situation. Many of the oils containing these

TABLE II. FOUR-CYCLE CRANKCASE LUBRICATION (VISCOSITY-GRADE) RECOMMENDATIONS OF MANUFACTURERS**

MANUFACTURER	Above 40°F.	Above 32°F.	Below 5°F.	Below 0°F.	Below -10°F.
Briggs and Stratton	SAE 30 or 10W-30	5W-20 or 10W			
Clinton	SAE 30		10W		5W
Kohler	SAE 30		SAE 10W	5W or 5W 20	
Wisconsin	SAE 30	SAE 20 or SAE 20W	10W		
Tecumseh	SAE 30		10W-30		

**The recommendations listed are for specific models only. Be sure to check the operating instructions for your engine.

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*These are discussed in detail in "Selecting and Storing Tractor Fuels and Lubricants," AAAE & VA.

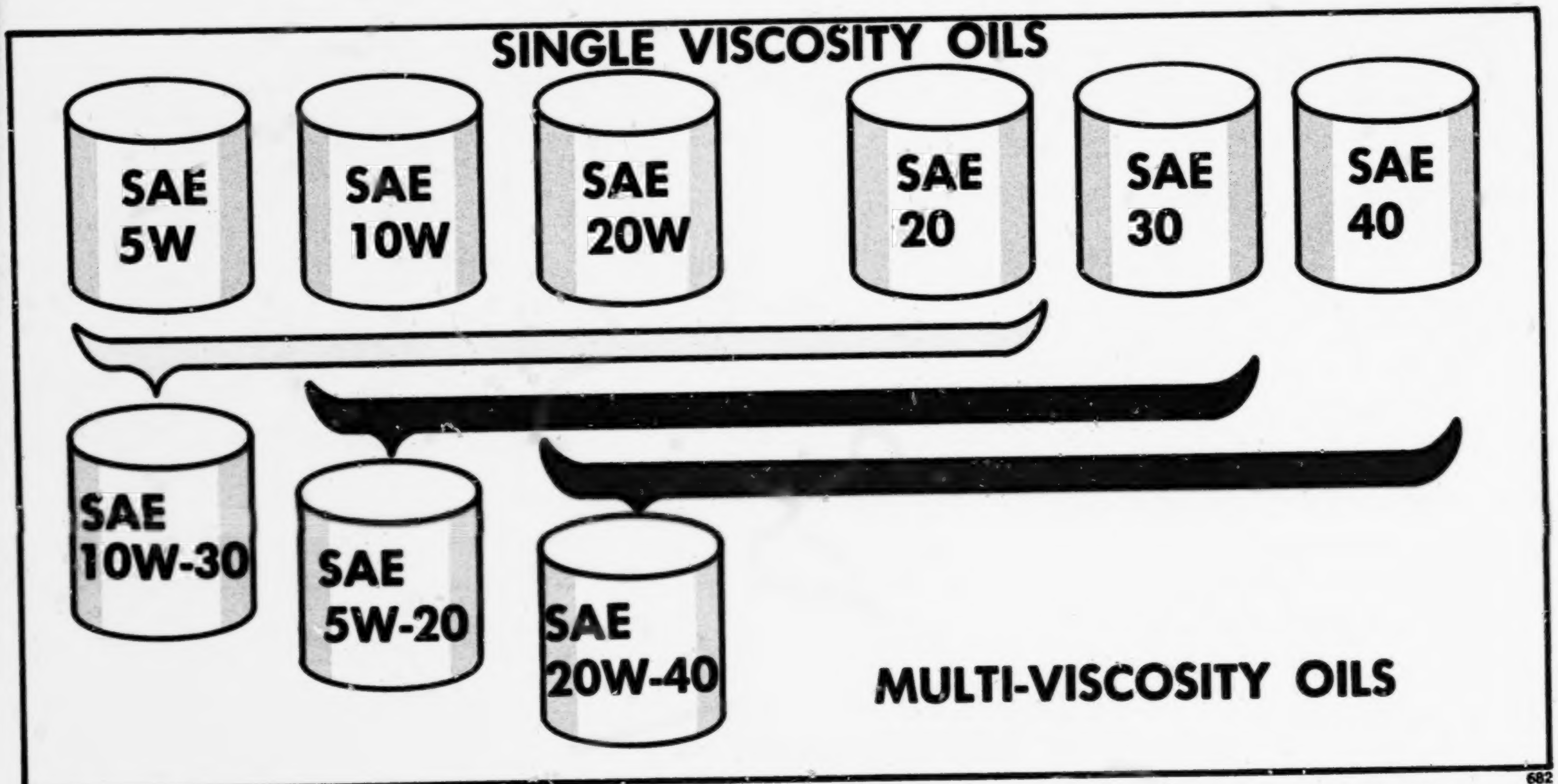


FIGURE 68. In 4-cycle engines you can substitute multi-viscosity grade oils for single-viscosity grade oils.

additives are marketed under the brand name of the manufacturer making the engine.

Oil **viscosity grade** is also important to consider when selecting oil for small engines. Viscosity is the resistance to flow. It is rated in SAE numbers as "SAE 30." Manufacturers recommend different viscosity grades for different temperatures. Table II gives viscosity-grade recommendations by five manufacturers for *4-cycle engines* when operated at different temperatures.

Note in Table II that there are *single viscosity-grade oils,* such as "SAE 30," and *multi-viscosity grade oils,* such as "SAE 10W-30." Figure 68 illustrates which multi-viscosity oils you can substitute for a single-viscosity grade oil and still meet the same requirements.

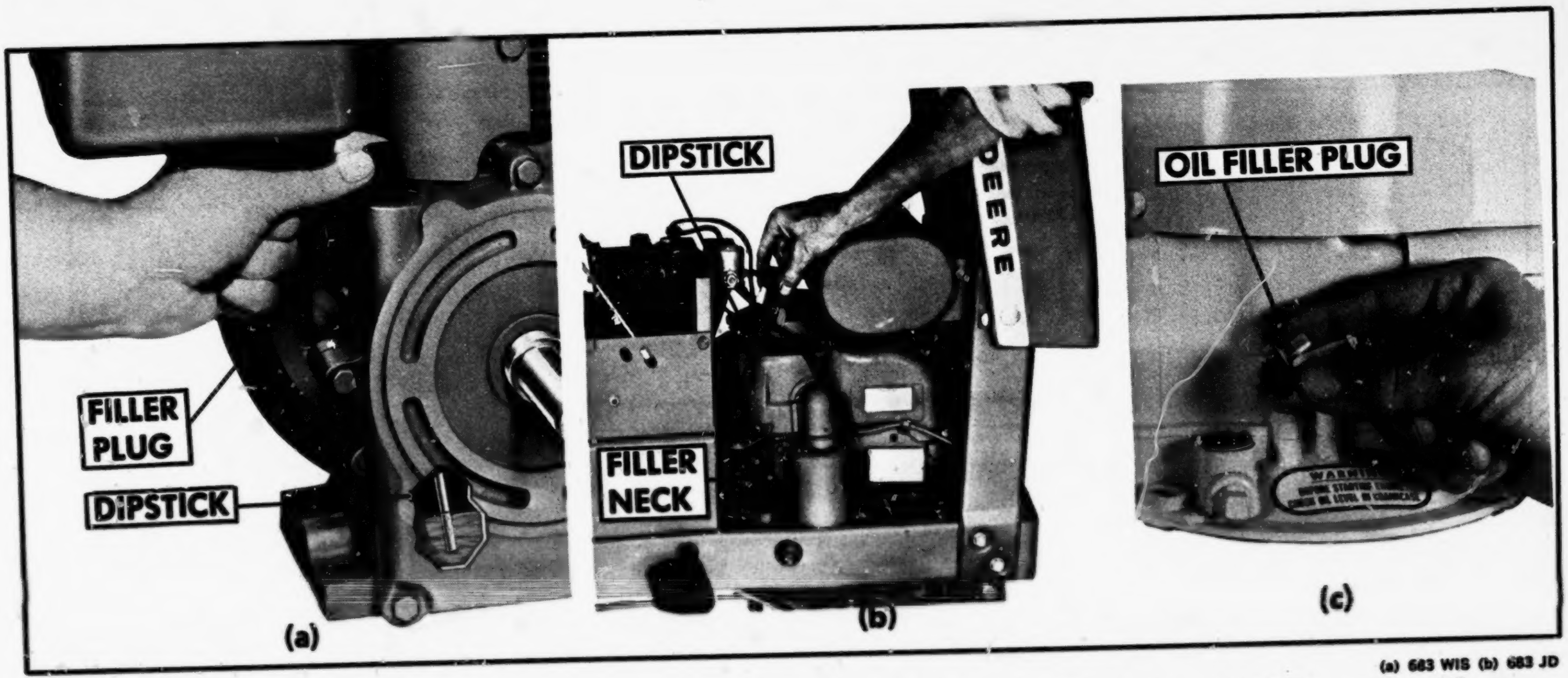
Most 2-cycle, and many **4-cycle, engine manufacturers,** however, recommend a *single viscosity grade oil* — usually SAE 30.

TOOLS AND MATERIALS NEEDED

1. Slot-head screwdriver — 8″
2. Combination pliers — 7″
3. End wrenches — 7/16″, ½″, 9/16″, and ⅝″
4. Funnel with a flexible spout
5. Oil as recommended
6. Container for old oil
7. Clean rags

CHECKING THE CRANKCASE OIL LEVEL (4-CYCLE ENGINES)

Check oil every 2 to 4 hours depending on the operating conditions and the recommendations of your manufacturer. A good policy is to *check the oil level each time you refuel* the engine. Proceed as follows:


FILLER PLUG
DIPSTICK
(a)
DIPSTICK
FILLER NECK
DEERE
(b)
OIL FILLER PLUG
(c)

(a) 683 WIS (b) 683 JD

FIGURE 69. Locations of oil-filler plugs ,or caps. (a) dipstick attached to the filler plug. (b) Filler neck with cap and dipstick. (c) Filler plug at top of oil sump.

1. *Locate the oil-filler plug or cap (Figure 69).*

   On small tractors you may have to raise the hood to get to the oil-filler plug.

   A **dip stick** may be attached to the filler plug on the crankcase (Figure 69a) or to a cap on the filler neck (Figure 69b). Some small engines have no dip stick. They have a filler plug at the top of the oil sump (Figure 69c).

2. *Clean dust or dirt from the filler plug or cap.*

   This procedure is to prevent dust from falling into the crankcase when the plug or cap is removed.

3. *Remove filler plug or cap (Figure 70).*

4. *Check oil level (Figure 71).*

   Be sure your engine is level.

   a. **If your engine has a dipstick,** proceed as follows:

      (1) *Remove dipstick.*

      (2) *Wipe dipstick with a clean rag.*

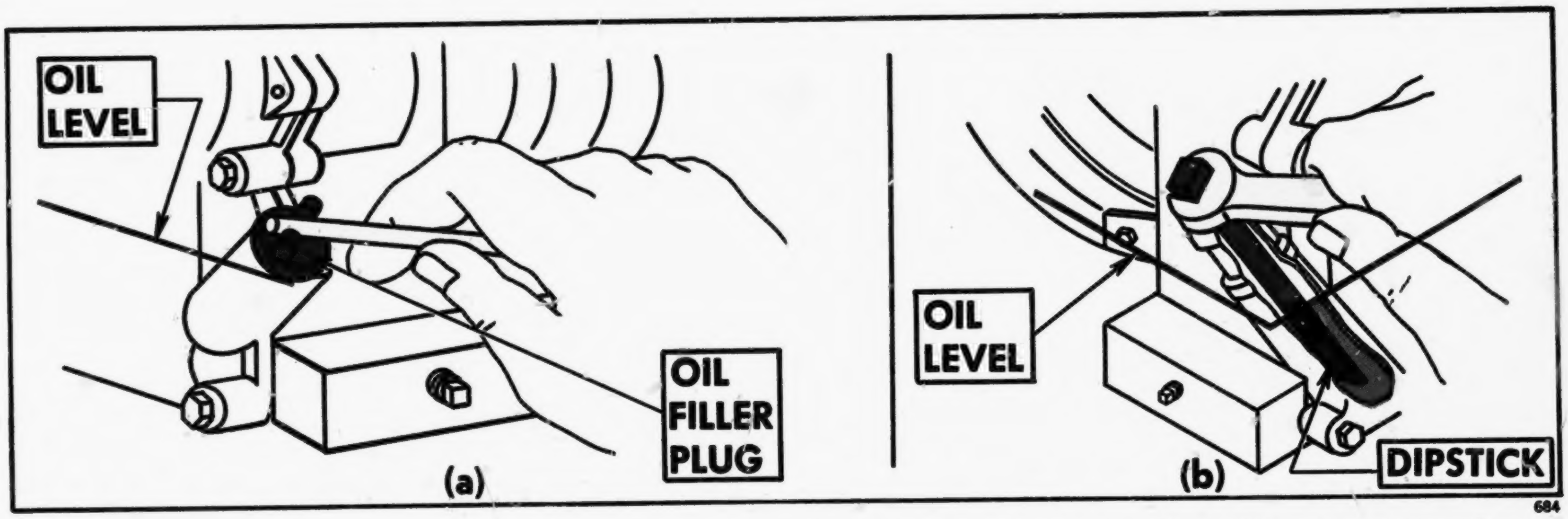

OIL LEVEL
OIL FILLER PLUG
(a)
OIL LEVEL
DIPSTICK
(b)
684

FIGURE 70. Removing a filler plug (a) using a metal rod about the size of a pencil, or (b) using a wrench.

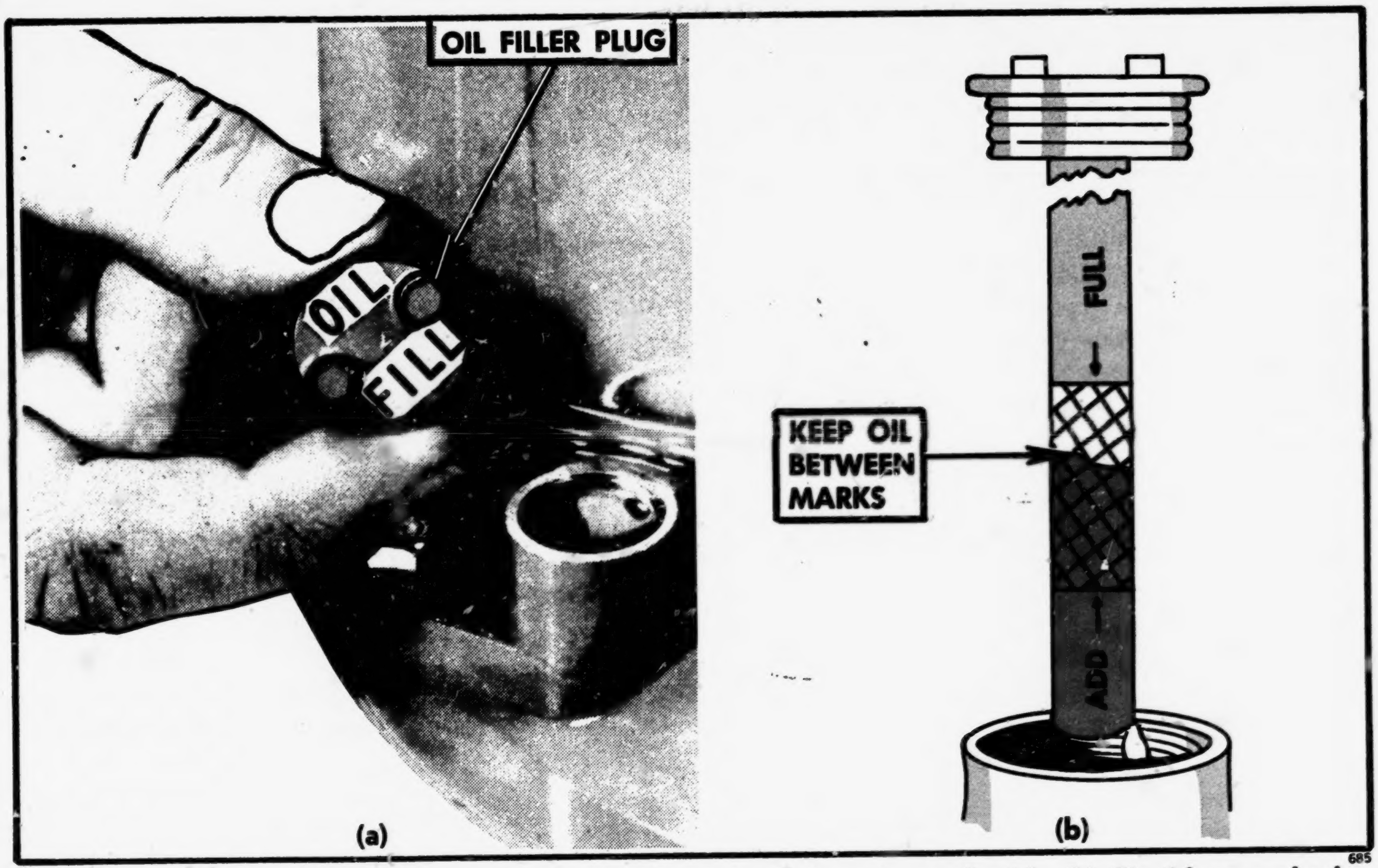


FIGURE 71. (a) Oil level should be to the top of the filler hole if there is no dipstick. (b) Dipsticks are clearly marked.

(3) *Re-insert dipstick.*

Insert dipstick as far as it will go, without attaching the plug or cap. It will extend into the oil sump.

(4) *Remove and check oil level.*

Oil should be between the marks shown in Figure 71b — never above the FULL mark or below the ADD mark. Most of them are marked according to the recommended practices established by the Society of Automotive Engineers (Figure 71b).

b. **If your engine has no dipstick,** check to see if the oil comes to the top of the filler hole, or to a marking or slot that indicates the FULL oil level.

5. *Check the oil condition*

Do not worry about the color of the oil. Additives in the oil cause it to change color as it cleans.

6. *Add or change oil.*

If the *oil is low and it is time for a change,* do not add oil; change it. Follow instructions under the next heading.

If you *add oil,* do not overfill. Overfilling may cause excessive oil consumption, oil may leak through the breather, or it may cause a hydraulic lock* on engines with horizontal cylinders.

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*Hydraulic lock in this case refers to oil filling the combustion chamber and being trapped by the valves, thus preventing the piston from moving.

7. *Replace plug or cap.*

Be sure the plug or cap fits snugly. If your crankcase operates on a partial vacuum, dirt will enter through any small opening that results from a poor fit.

CHANGING THE CRANKCASE OIL (4-CYCLE ENGINES)

You may have heard the comment that oil does not wear out. The truth of this statement depends on what oil qualities you have in mind. It is true that oil does not wear out in the sense that it remains slippery. In other important aspects it gradually becomes unfit for use.

Oil collects dirt particles, soot, sludge, varnish-forming materials, metal particles, water, and gasoline. A point is finally reached where the oil is unable to absorb additional contaminants and still be effective as a lubricant. When the oil becomes "loaded," varnish deposits start to form on the piston and rings, and sludge collects in the crankcase. On a small engine there is no oil filter to help filter out metal and large grit particles. These accumulate and increase wear.

How much wear increases with longer oil-change intervals was measured by Gow[4] in a series of severe duty tests with automobile engines. They were operated under low-temperature crankcase conditions such as exist with stop-and-go driving. Measurements were taken on the rate of piston-ring wear. It was found that the rate of wear increased rapidly as the time between oil changes was increased.

No similar studies have been reported for small engines; but under the same operating conditions, it is assumed that the wear rate would be similar.

Manufacturers' oil-change recommendations vary from every 10 to every 50 hours of engine operation. These intervals are timed so the oil in your engine should not reach the "loaded" stage of contamination if you are maintaining your engine properly.

After the first 2 to 5 hours of operation, oil should be changed in a **new engine** to get rid of metal particles.

Steps for changing oil in your engine are as follows:

1. *Operate engine until it is thoroughly heated.*

   Oil will drain more completely while hot. Also more contaminants are removed while the oil is still agitated.

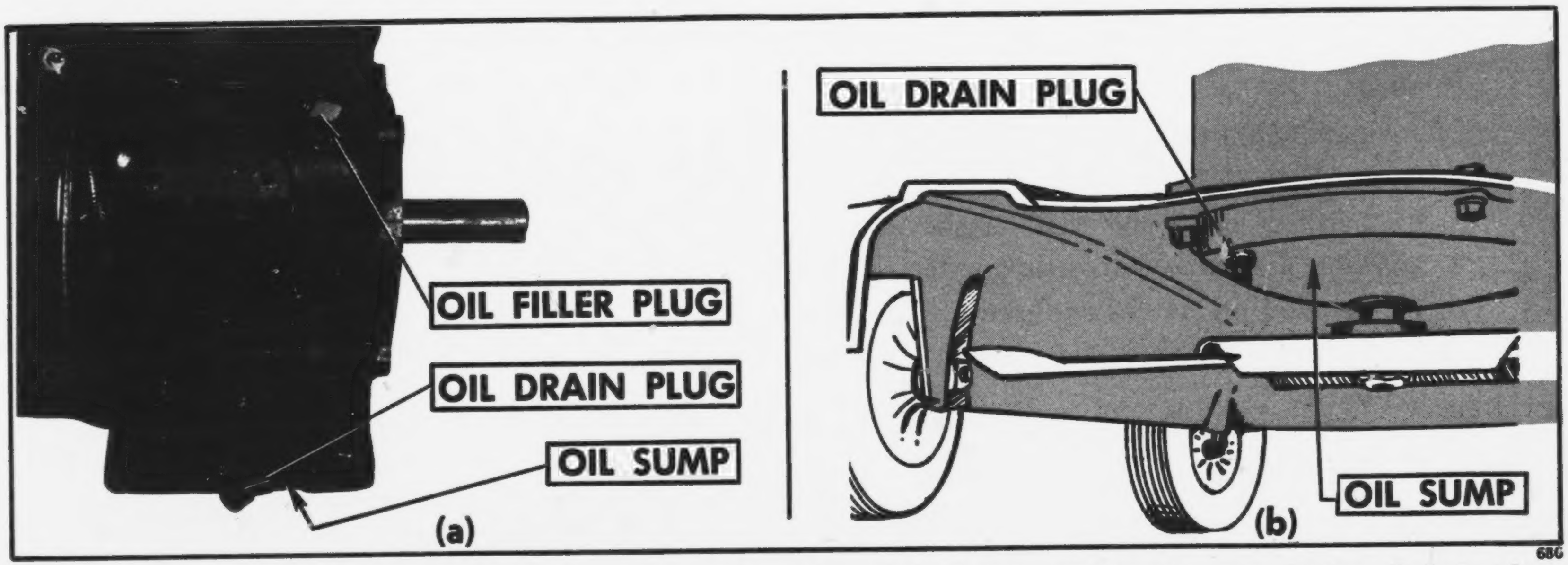


FIGURE 72. (a) An oil drain plug located on the outside edge of the bottom of the oil sump. (b) An oil drain plug located in the bottom of the oil sump.

If the crankcase is drained while the oil is cold, some of the more highly contaminated oil may remain in the engine.

2. *Stop the engine and disconnect the spark-plug wire.*
3. *Locate the drain plug.*

   Most drain plugs are located on the outside edge of the bottom of the oil sump (Figure 72a). Some are located under the oil sump Figure 72b).

   Some engines have no drain plug and are drained through the filler neck.
4. *Clean dirt from around plug before removing it.*
5. *Remove drain plug.*

   Use a wrench that fits the drain plug, not a pair of pliers. Pliers will gradually round off the corners of the plug until it will be difficult either to remove or to tighten the plug.
6. *Allow crankcase to drain for approximately five minutes.*

   This allows time for the oil to drain from various parts of the engine. This drainage is important in order to remove as much dirt and oil as possible.

   If the drain is in the side or top of the sump, tilt the engine towards the drain.

   If your engine is drained from the filler neck, tilt it over on the filler-neck side until the oil drains.
7. *Replace drain plug.*

   If drain plug is equipped with a gasket, be sure to install it.
8. *Refill crankcase with new oil.*

   Use the viscosity and type of oil recommended in your operator's manual. See Table II, page 62.

   Use the amount of oil recommended for your engine.

   Be sure the tops of the oil cans are thoroughly cleaned. Check the funnel, or any container you may be using, to make sure it is free of dirt.

   Wipe away excess oil around filler plug.
9. *Connect spark-plug wire and start engine.*

   Operate it for a few minutes.

   This gives the oil an opportunity to establish a true level on the dipstick.
10. *Check for oil leaks.*
11. *Stop engine.*
12. *Re-check oil level.*

    If oil is **not to the "full" line,** add more until it reaches that level. *Do not overfill.*
13. *Clean or destroy oily rags.*

    Do not store them. They may cause spontaneous combustion.

STORING CRANKCASE OIL

It is not unusual to have part of a can of oil left after adding or changing oil in your engine. If you plan to use the remainder of the oil at a later date, it should be protected against (1) dirt, (2) moisture, and (3) heat. The plastic tops on vacuum packed food cans are ideal for covering quart oil cans (Figure 73).

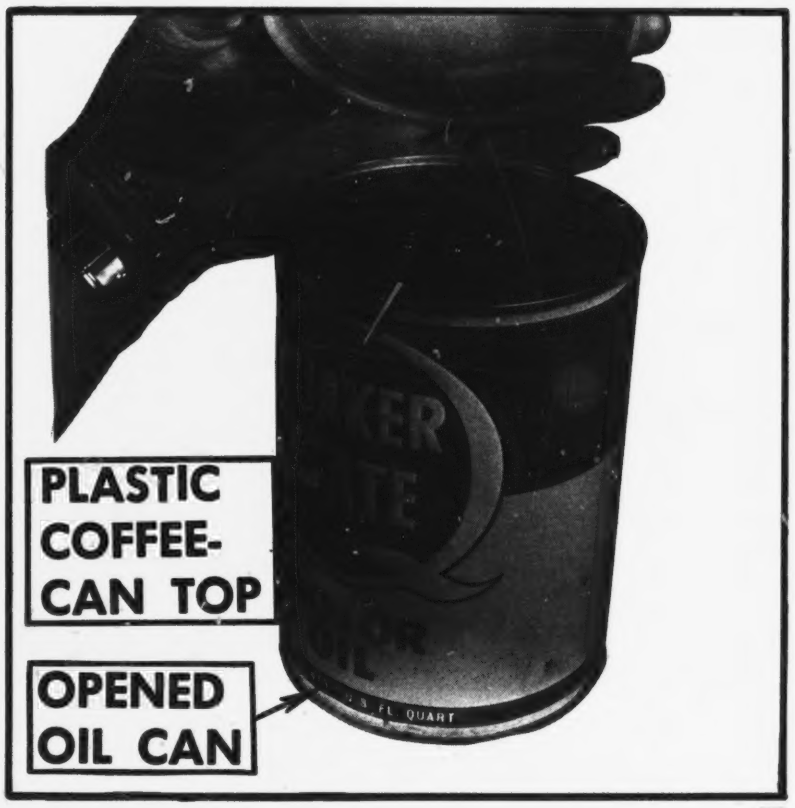
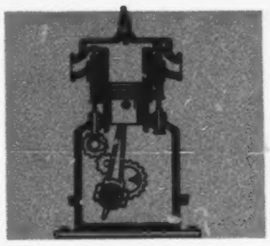


FIGURE 73. Opened oil cans should be sealed to protect the oil from dirt.

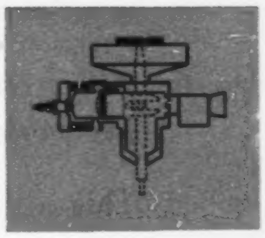
If you keep oil in large cans with screw caps, be sure to keep the tops on and tight.

Store oil in a clean, dry place.



G. REFUELING SMALL ENGINES

(FUEL SELECTION-USE-STORAGE)



Figures 5 and 6 show how the chemical energy of gasoline and air are converted to mechanical energy in small gasoline engines.

Gasoline is ideally suited for spark-ignition engines for several reasons. The more important of these are the following:

- *Gasoline vaporizes readily.*

  Petroleum products will not burn when in a liquid state. They must first be evaporated and mixed with air. Since gasoline vaporizes readily, it helps assure easy starting and complete combustion during operation.

- *Gasoline burns at a relatively moderate speed.*

  The fuel in the combustion chamber must not explode. It must burn at a smooth, even rate. Gasoline does this, thus preventing knock.

- *Gasoline comes in different octane ratings.**

  Different engine designs require gasolines with different octane ratings. The higher the engine compression ratio, the higher the octane rating required for smooth, even burning.

---

*If you do not understand the meaning of "octane-number rating," the following discussion will help. The octane rating is a method of comparing the anti-knock qualities of fuels used in spark-ignition engines with standard test fuels. It has been established by the ASTM (American Society for Testing Materials). The lowest number on the octane scale is 0. Fuels near that end of the scale have a bad tendency to knock; kerosene is one of them. Fuels with the least tendency to knock have higher octane numbers, some even higher than 100. LP-Gas and super-premium gasoline are examples of these.
Refer to "Selecting and Storing Fuels and Lubricants," AAAE & VA, for a complete discussion on octane ratings of gasoline.

You might think that anyone should be able to put gasoline in an engine properly. There are several facts, however, about selecting fuels, about preparing them for 2-cycle engines, and about the method you use when filling the tank that are important for you to know. They are discussed under the following headings:

1. Selecting the fuel.
2. Tools and materials needed.
3. Preparing fuel for 2-cycle engines.
4. Filling the fuel tank.
5. Storing fuel.

SELECTING THE FUEL

The octane rating (anti-knock quality) of **regular grade** gasoline (90-92 octane) is sufficient for the compression ratio of most small engines. Their compression ratio is usually 6 to 1, or 7 to 1 (Figure 74). If you use gasoline with too low an octane number for the compression ratio of your engine, the fuel will burn unevenly and detonate, or "knock" (Figure 75).

A few years ago small engine manufacturers recommended "marine white," or unleaded gasoline for their engines. But new engine designs, and the fact that most regular grade gasolines contain anti-deposit additives which help prevent the harmful deposits of lead, have eliminated the need for unleaded gasolines. Unless the manufacturer of your engine recommends premium-grade gasoline for your engine, you are paying more for fuel than is necessary.

Detonation occurs when the fuel burns unevenly. Part of the fuel charge in the combustion chamber is ignited by the spark plug. The unburned portion of the fuel mixture becomes compressed until its temperature reaches the point of self-ignition—as in a diesel engine. This causes knock, or detonation. Detonation causes a hammering force on the piston rather than a uniform pushing force (Figure 75c).

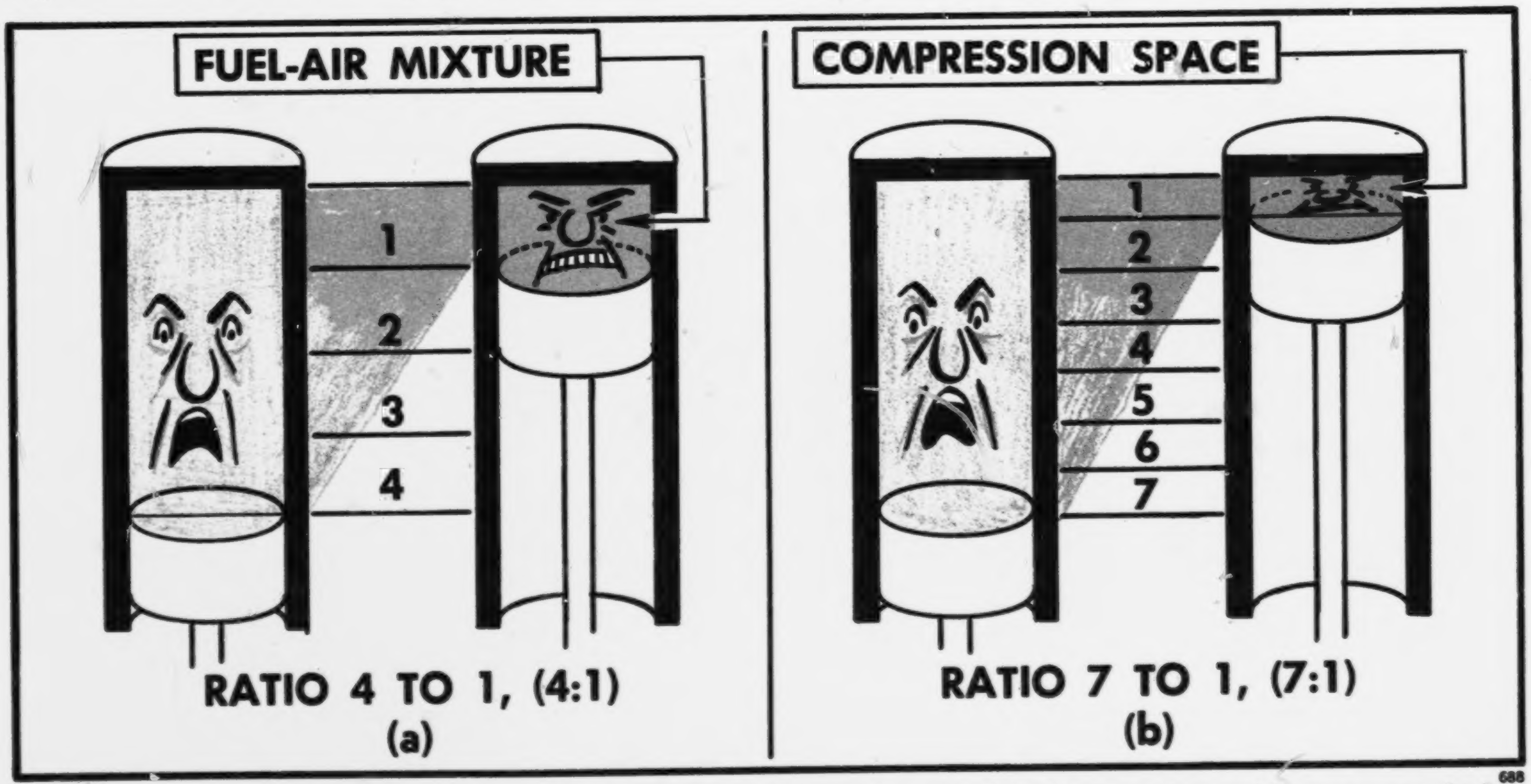


FIGURE 74. For satisfactory operation and economy, a fuel must be matched with the proper compression ratio of the engine. (a) Heavier fuels (kerosene, distillate) must be used in spark-ignition engines with a comparatively low compression ratio. (b) Regular gasoline works best with a compression ratio of about 6:1 to 7:1 and higher.

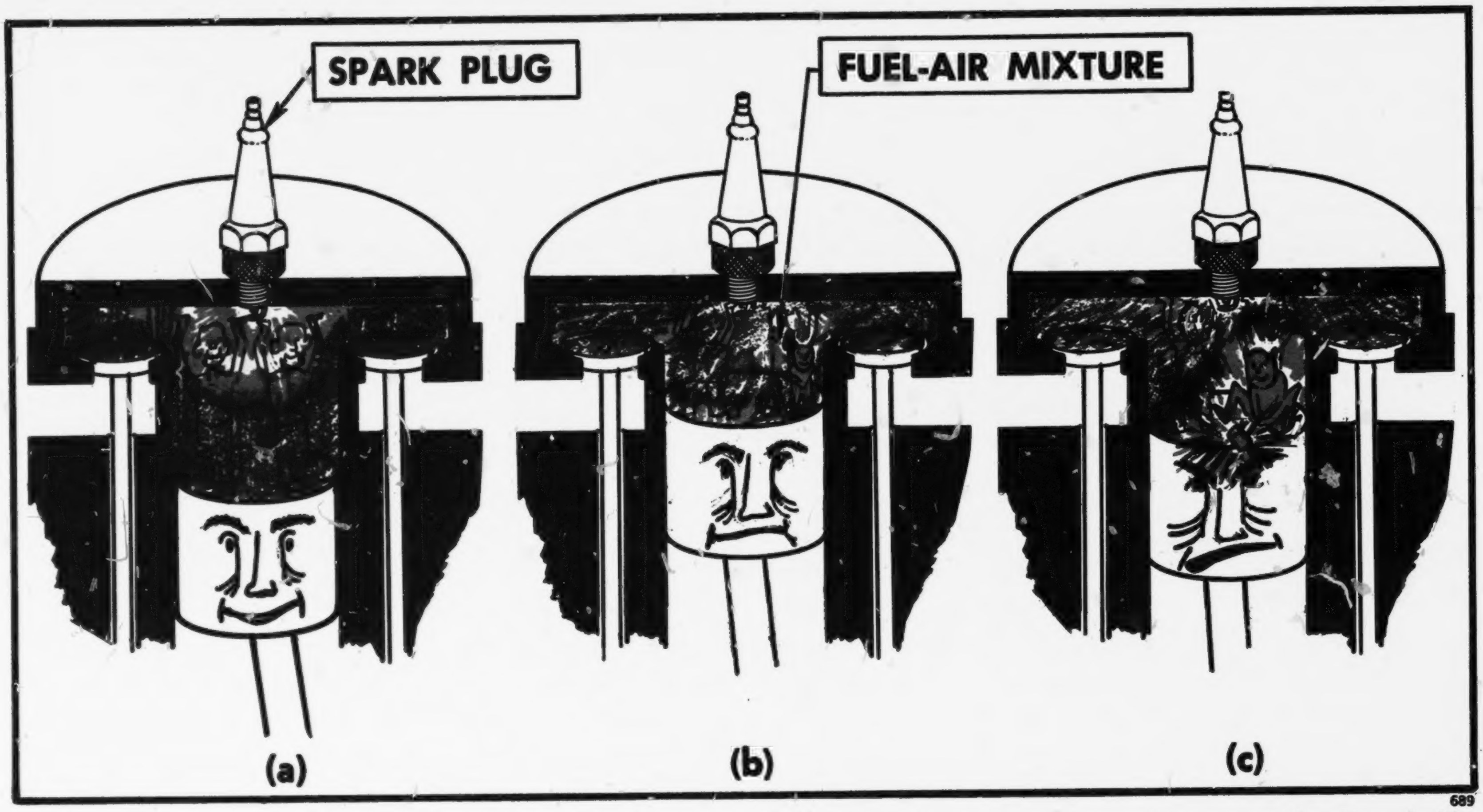


FIGURE 75. How fuel knock (detonation) develops. (a) Fuel is ignited next to the spark plug. (b) Fuel burns unevenly. Tremendous pressures build up on unburned portion of fuel. (c) Pressure and temperature become high enough to cause spontaneous combustion (self-ignition) of the unburned fuel resulting in a miniature explosion, or "knock."

Detonation will cause your engine to lose power, and the engine may even suffer serious piston damage (Figure 76). Your engine will also operate at a higher temperature. Prolonged operation at excessive temperatures will cause valve burning.

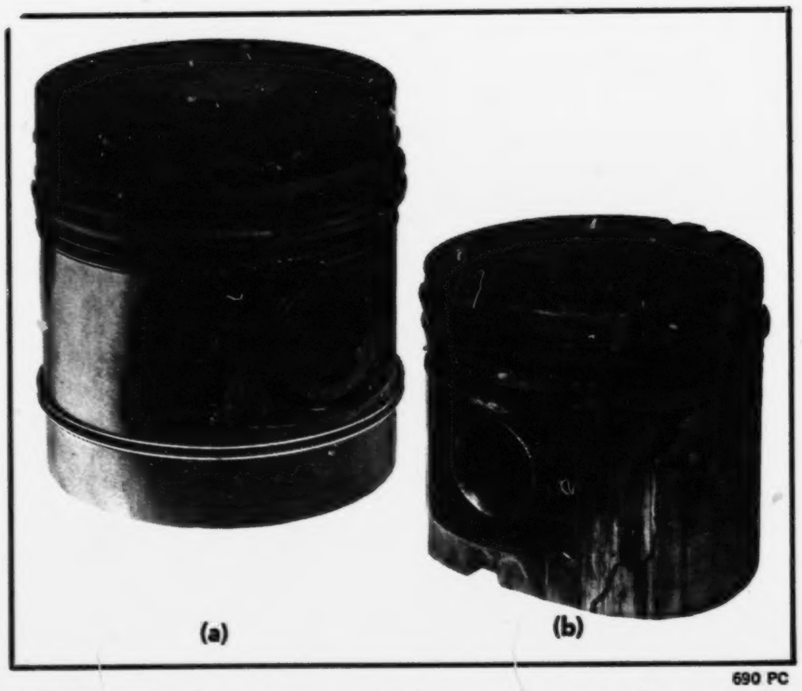


FIGURE 76. The violent "fuel knock" explosion usually occurs on the side of the cylinder opposite the spark plug. (a) Damage occurs at the edge of the piston. (b) Damage can be severe enough to crack the piston.

Provisions for easy starting are also built into fuels by producers of gasoline. It is fitted to the climatic conditions in the area in which it is sold. In summer, oil companies blend their gasoline so volatility (its tendency to evaporate) is low. Therefore, if you use summer gasoline after the weather turns cold, you may have trouble starting your engine because of its low volatility.

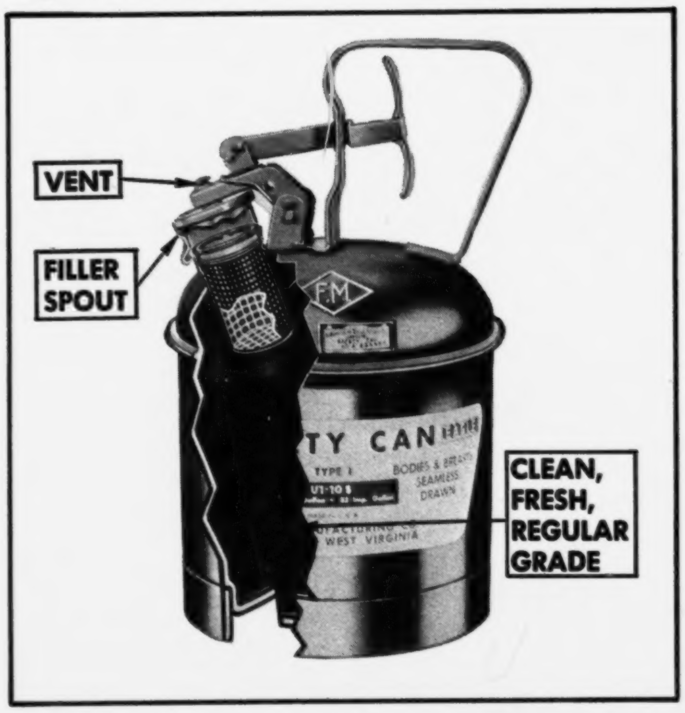


FIGURE 77. Purchase gasoline in small quantities to assure freshness. Store in a sealed metal container.

In winter, oil companies blend their gasoline so volatility is high for easy starting. If you use winter gasoline after the weather gets warm, you will have more loss from evaporation.

The only control you have over volatility is to buy small quantities of gasoline and store it properly so as to keep down evaporation. How to store gasoline is discussed under "Storing Fuel," page 73.

Besides providing fresh regular-grade gasoline, it is important that it be clean (Figure 77). If the gasoline you use is not clean, you are in trouble. Dirt and trash will clog the fuel strainers and require frequent servicing. Particles that get past the fuel strainers may clog the tiny carburetor jets. Your engine will not run properly — or it may not run at all. Small particles of dirt which get past the carburetor jets and go into the engine are still a greater hazard. They combine with the crankcase oil to form a grinding compound and cause rapid engine wear.

TOOLS AND MATERIALS NEEDED

1. Funnel and strainer
2. Clean, fresh, regular gasoline
3. Oil as recommended — for 2-cycle engines (Most manufacturers recommend SAE 30 or 40 non-detergent (ML) oils. Some recommend multi-viscosity oils. Many manufacturers supply their own brand of oil.)
4. Fire extinguisher

PREPARING FUEL FOR 2-CYCLE ENGINES

Use clean, fresh, regular-grade gasoline as discussed under "Selecting the Fuel", and use SAE 30, non-detergent crankcase oil (API classification ML) unless otherwise directed in your operator's manual or on your engine nameplate.

The *amount of oil you mix with the gasoline is critical.* For most engines you can mix ½ pint of oil to 1 gallon of gasoline. Recommendations vary, however, from ¼ pint to 1 pint per gallon, depending on the engine design, horsepower, size, and engine speed. Follow the directions in your operator's manual.

The addition of *more oil than is recommended* will cause poor combustion and the formation of gum, varnishes, and carbon deposits. The exhaust ports will become clogged; pre-ignition will occur; and the engine will lose power and eventually stop running.

Too little oil may result in inadequate lubrication, which greatly increases wear on moving parts.

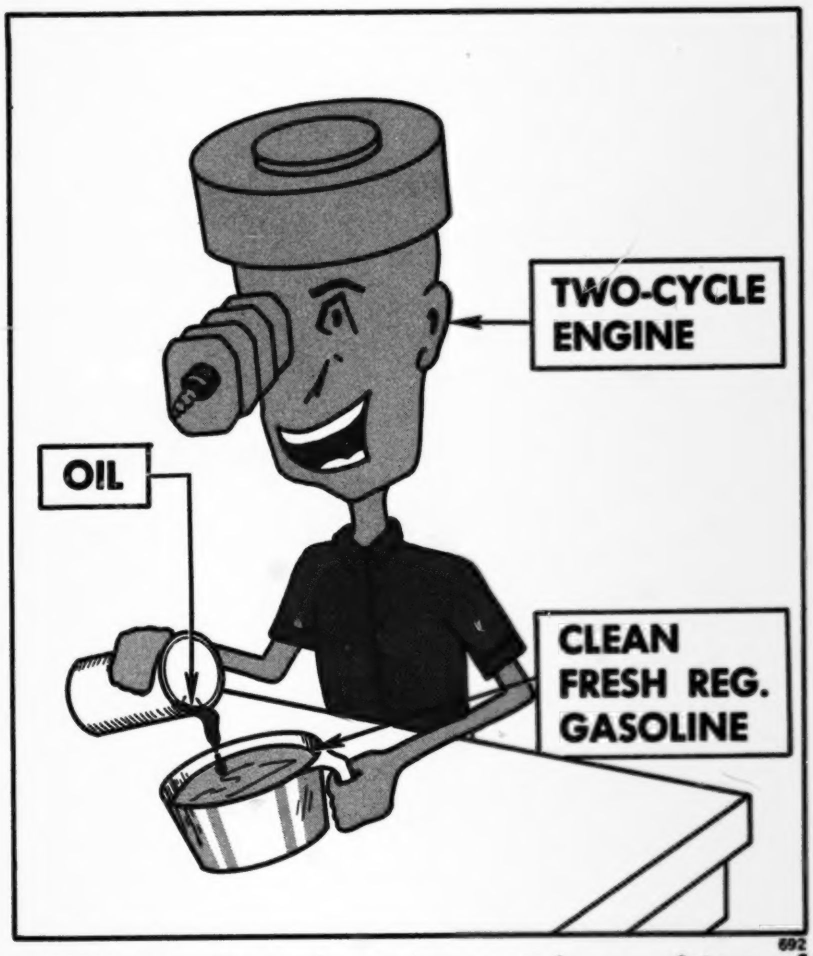


FIGURE 78. Two-cycle engines require a mixture of gasoline and oil.

The method of mixing oil and gasoline in the fuel tank is also important. Once mixed, oil and

and gasoline do not separate, but they are not easily mixed.

To assure a **proper mixture of fuel** for your 2-cycle engine proceed as follows:

1. *Secure an adequate-size enclosed can for mixing (Figure 79).*

   The container should have twice the capacity of the amount of fuel you intend to mix.

   Make sure it is clean.

2. *Fill container ¼ full of fuel.*

   If possible, strain the fuel through a clean 120-mesh strainer to remove any trash or dirt.

3. *Add oil to the gasoline.*

   Use the oil recommended by your manufacturer.

4. *Shake the can vigorously.*
5. *Add more gasoline until container is ½ full.*
6. *Shake the can again.*
7. *Keep can tightly closed and well marked when not in use.*

FILLING THE FUEL TANK

Gasoline is very flammable. Just because you have seen others get by with careless handling of gasoline does not mean that you may be as fortunate.

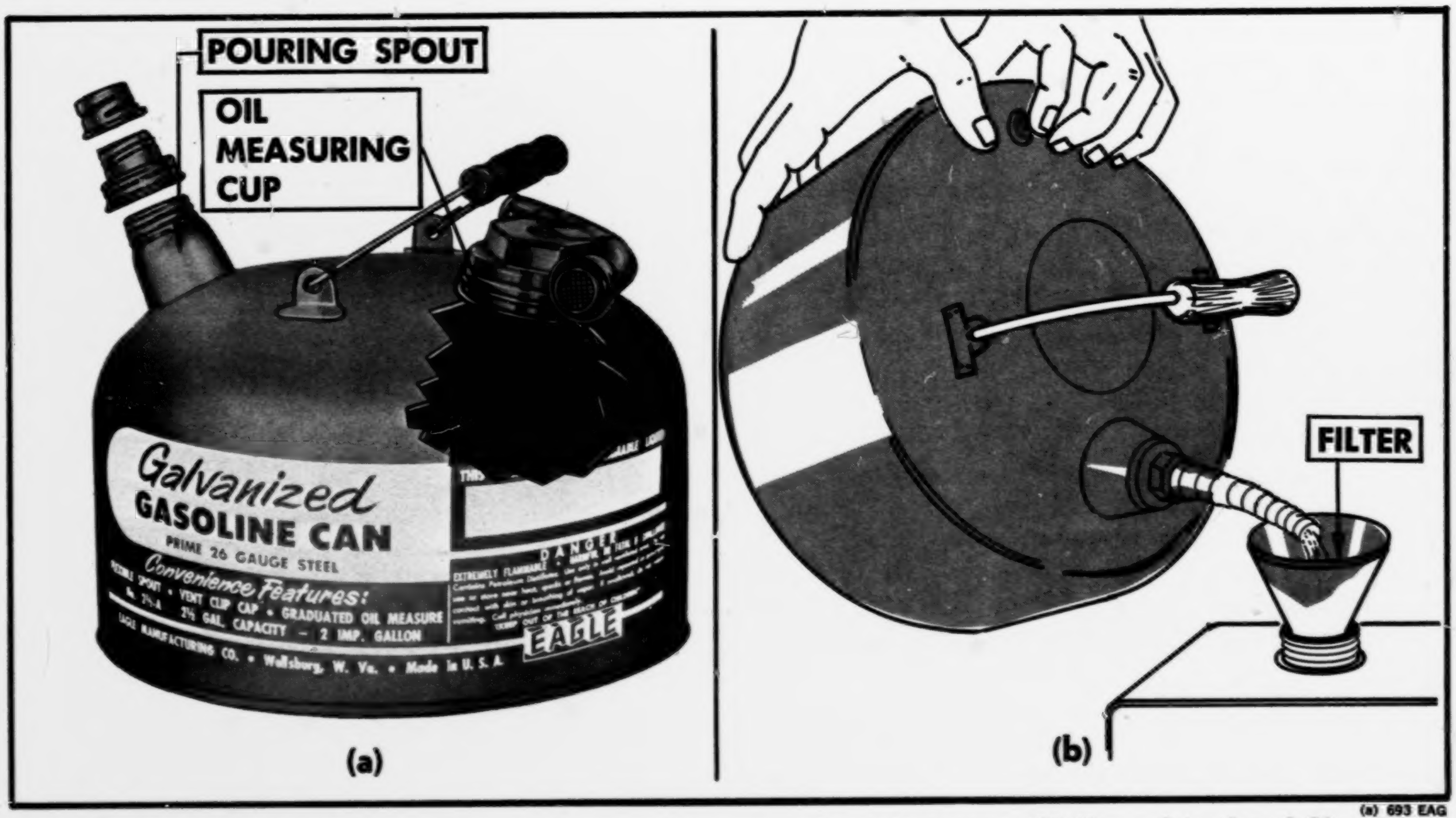
Steps for filling the fuel tank are as follows:

1. *Stop engine, if it is running.*

   Allow engine to cool if it is extremely hot.

2. *Locate the fuel-tank filler cap.*

   On some small tractors you will have to raise the hood. Check gasket in tank cap. Replace it if it does not seal.


POURING SPOUT
OIL MEASURING CUP
Galvanized
GASOLINE CAN
PRIME 26 GAUGE STEEL
Convenience Features:
GRADUATED OIL MEASURE
2½ GAL. CAPACITY – 2 IMP. GALLON
DANGER
EAGLE
(a)
FILTER
(b)

(a) 693 EAG

FIGURE 79. (a) Fuel container with an oil measuring cup and pouring spout. (b) Use a funnel and filter when filling the fuel tank.

3. *Wipe dust and dirt from around the filler cap.*

4. *Remove filler cap.*

   Do not smoke or light a match near the open fuel tank. It is an unnecessary fire hazard.

5. *Check visually the fuel level in the tank.*

   Never put a dirty stick in your tank to check the fuel level.

6. *Refill the tank if necessary (Figure 79).*

   Use a funnel and a 120-mesh filter if possible. When pouring fuel, keep the nozzle in contact with the metal fuel tank. Fuel movement can cause static electricity. This contact grounds the electrical charge and avoids any risk of igniting the gasoline vapors.

   If fuel is accidentally **spilled,** wipe it away with a rag.

7. *Replace fuel-tank filler cap securely.*

8. *Fasten the hood if it was opened.*

9. *Store remaining gasoline.*

STORING FUEL

Each state has its own laws regarding storage and use of fuels. It is important that you become acquainted with them for your own safety and for insurance purposes. In general, state laws are based on the standards and codes established by the National Fire Protection Association. Their recommendations are followed in this discussion.

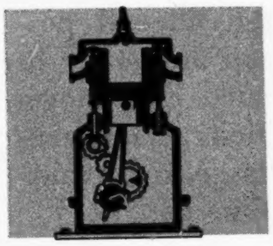
Your safety, the ease with which the engine starts, and the amount of maintenance required for proper operation of the fuel system on the engine — all are affected by the way you handle and store the fuel.

The primary concern in the storing of gasoline is **safety.** Never store fuel in a tightly closed room where gasoline vapors will accumulate. This is especially true if you have a gas water heater in the storage room. Store in an approved metal container (Figure 79a) in a cool, dry place, away from children.

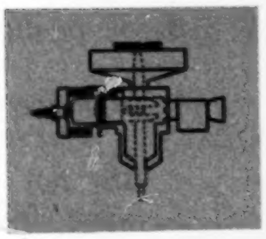
Gasoline in small containers may begin to form **gums and varnishes** after being stored for a time (1 to 4 months) in the fuel tank or in a container. You can usually recognize stale gasoline by its foul odor.

Gums and varnishes in stale gasoline interfere with proper engine operation. Carburetor jets become clogged, spark plugs are fouled, and valves and piston rings stick. Eventually, valves burn and piston rings break. Engine failure follows.

Some gasolines break down under storage quicker than others, depending on the additives in the gasoline, the type of storage, and the length of time the gasoline is held in storage before you buy it. To be on the safe side, purchase gasoline for your small engine from a reliable dealer—and in small quantities.



H. SERVICING SPARK PLUGS



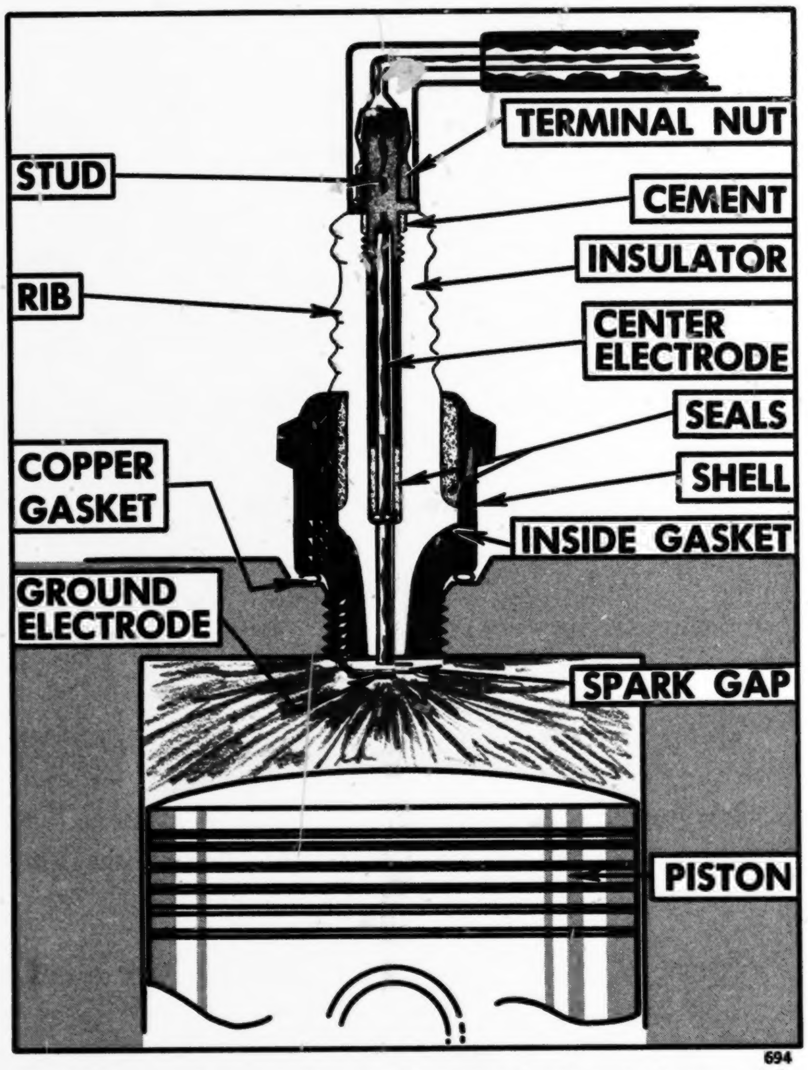


FIGURE 80. The function of the spark plug is to provide a spark in the combustion chamber.

The spark plug provides a means whereby a spark can occur inside the combustion chamber (Figure 80). This is how it works.

- Electric current from the magneto or ignition coil travels at regular intervals through the high-tension lead wire to the spark-plug terminal.
- The current is conducted through the center electrode to the spark gap.
- High voltage (10,000 to 20,000 volts) pushes the current across the spark gap to the ground electrode.
- As the current jumps the gap, a spark is formed—very similar to a minature bolt of lightning.
- The fuel-air mixture in the combustion chamber is ignited by the spark.

A fouled spark plug is a common ailment among small engines — one that most operators should be able to detect and correct. How to detect and how to correct spark-plug troubles are discussed under the following headings:

1. Types of spark plugs.
2. Importance of proper maintenance.
3. Tools and materials needed.
4. Checking the spark plug for proper operation.
5. Inspecting and servicing the spark plug.
6. Installing the spark plug.

TYPES OF SPARK PLUGS

Whether you are buying a new spark plug or reconditioning an old one, it is important that you understand the differences in spark plugs and how they affect the operation of your engine.

Your operator's manual indicates the size and type of plug that best fits your particular engine.

These are also given on charts by various spark-plug

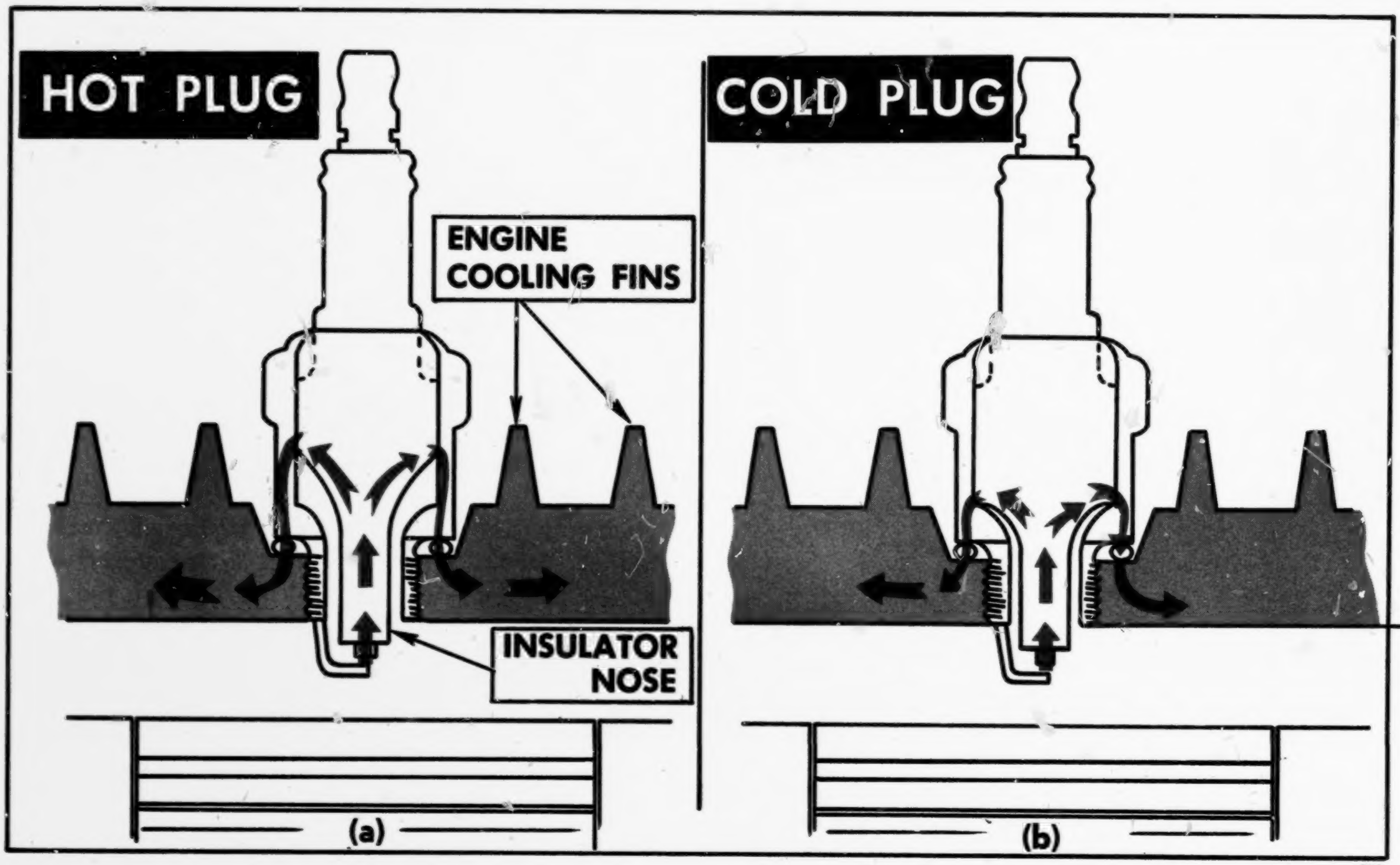


FIGURE 81. Spark plugs are available by heat types. (a) Hot type has a long insulator nose. Heat must travel farther to reach the cooling fins. It stays hotter than (b) the cold type, with a shorter insulator nose. (Normal type is not shown.)

manufacturers. Your job is to be sure and not substitute some type of plug that happens to appeal to you or appears to work all right.

There are several sizes and types of spark plugs developed to meet most any combination of the following:

- *Operating conditions* — whether the engine operates under heavy load, light load, or moderate load.
- *Kind of fuel used.*
- *Engine design.*

Operating conditions vary from *light loads to heavy continuous loads* where the engine stays hot continuously. To meet these varying conditions and to provide the most satisfactory performance from your engine, manufacturers make available "cold," "normal," and "hot" spark plugs. The difference in the three types is the *length of the insulator tip* — its length determines how rapidly heat passes from the spark plug to the engine cooling fins (Figure 81).

The longer the insulator tip, the further the heat must travel, and the hotter the plug becomes (Figure 81a). Consequently, a "hot" plug is needed in an engine that does not reach relatively high operating temperatures.

The terms "hot," "normal," and "cold" refer to the *operating temperature of the plug,* not to the intensity of the spark.

By using a spark plug of the **proper heat type** you get longer, trouble-free service from it and from your engine. The spark plug *becomes hot enough to burn itself free of carbon.* It will not become hot enough to overheat and burn the electrodes, thus widening the spark-plug gap. Check the chart in Figure 82 and note the wide range of temperatures through which plugs are self-cleaning.

If you use a **hot plug under heavy load conditions,** you can expect it to overheat. Overheating will

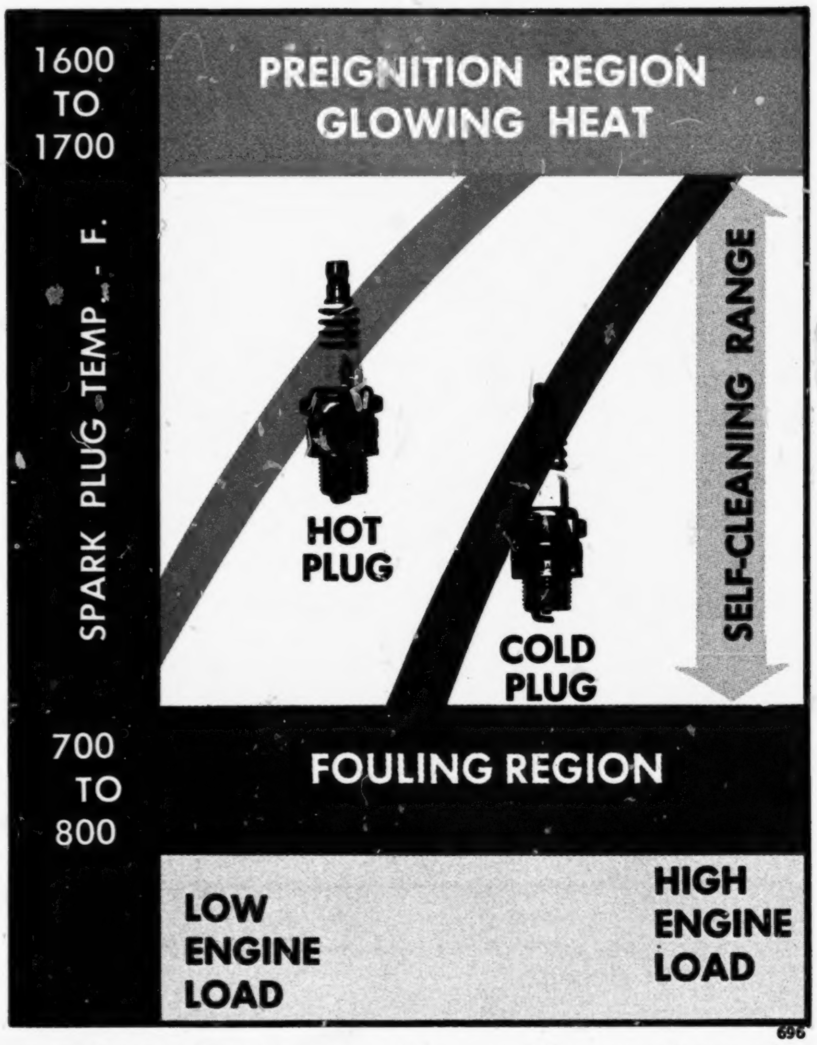

1600
TO
1700
PREIGNITION REGION
GLOWING HEAT
SPARK PLUG TEMP. - F.
HOT
PLUG
COLD
PLUG
SELF-CLEANING RANGE
700
TO
800
FOULING REGION
LOW
ENGINE
LOAD
HIGH
ENGINE
LOAD
696

FIGURE 82. Hot plugs stay cleaner while operating under light load conditions than cold plugs. Under heavy loads a cold plug is slower reaching the pre-ignition

cause blistering, burning of the electrodes, lead fouling, and engine knock. Knock is caused by the plug becoming so hot it ignites the fuel charge before the spark plug fires. In Figure 82 this is shown as being around 1600° to 1700°F.

If you use a **cold plug under extensive idling and light-load conditions,** you can expect it to foul with carbon — the plug will not get hot enough to burn off the carbon. This causes the engine to skip. There will be a gradual build-up of carbon inside the combustion chamber. Figure 82 shows this condition at 700° to 800°F. and below.

Engine design affects the **length of "reach"** of plug recommended. This fact is particularly true in 14-millimeter sizes, which is one of the most common sizes used in small engines. Note in Figure 83 that there are 4 different "reaches" of 14-millimeter plugs. These are designed to fit different depths of engine heads so that the base of the plug will be even with the inside of the combustion chamber.

If a longer reach plug is used than is recommended for your engine, it will extend into the combustion chamber and may interfere with piston or valve action. The exposed threads on the plug will also collect deposits and the plug will be hard to remove (Figure 84a).

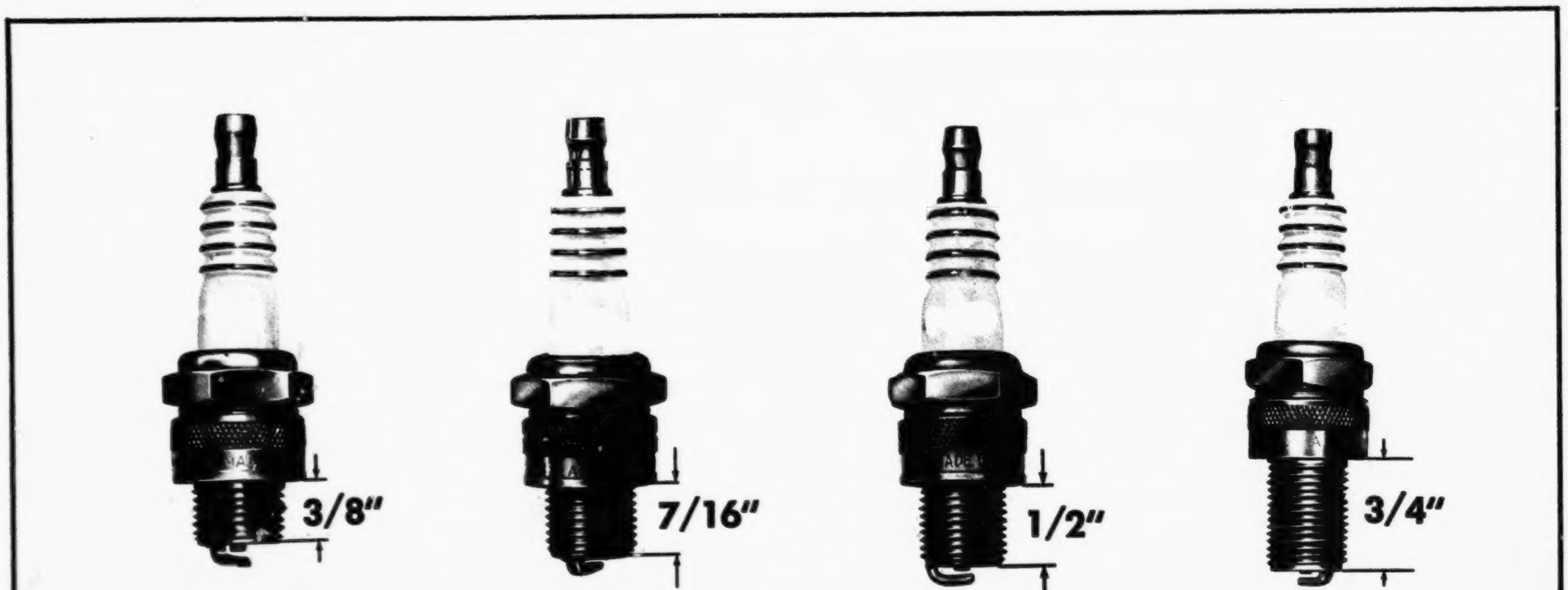

3/8"
7/16"
1/2"
3/4"
697

FIGURE 83. Spark plugs are made with different "reaches" to fit different engine-head thread depths. Most small engines use plugs with the shorter reaches.

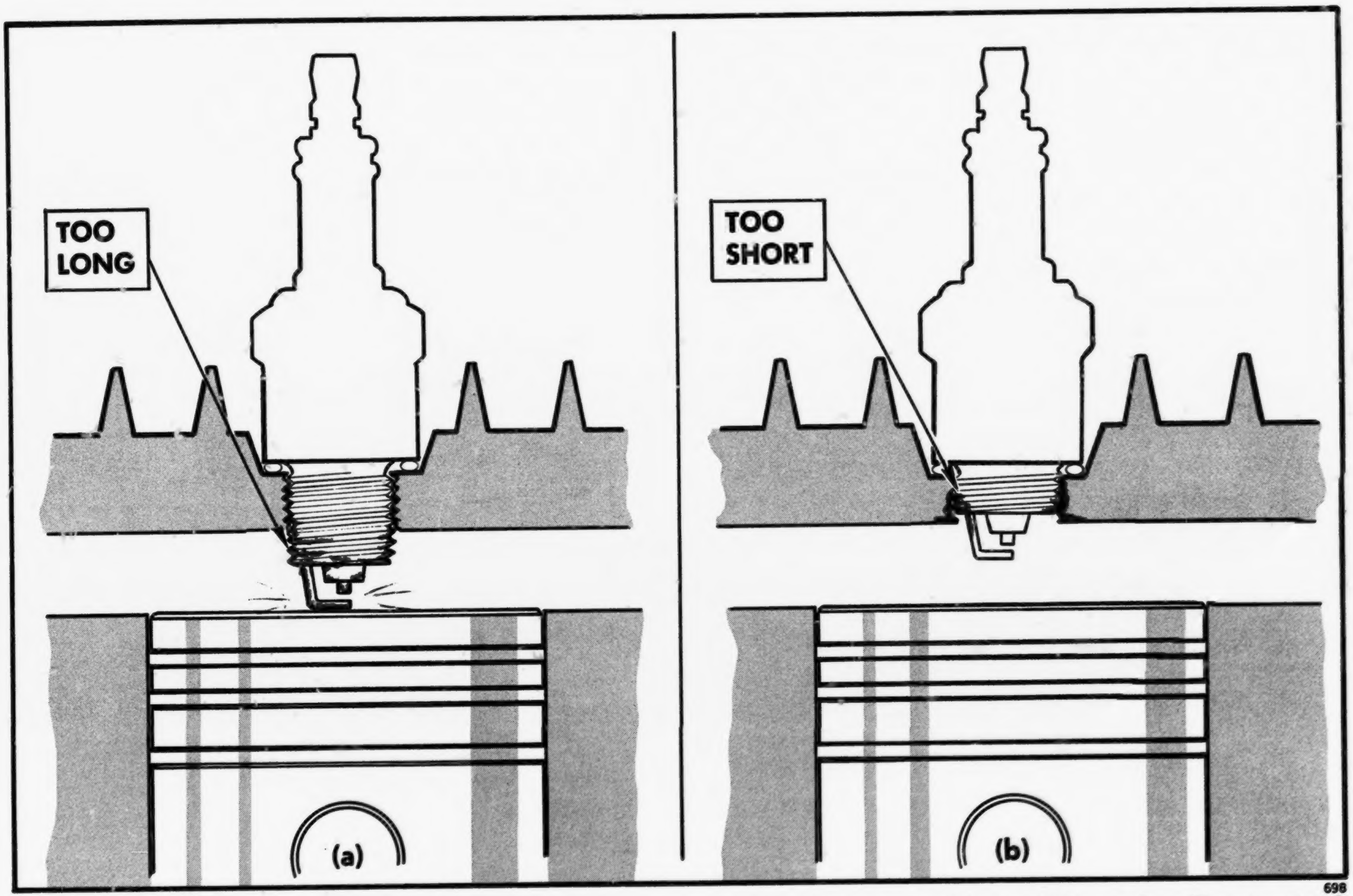


FIGURE 84. (a) A plug with too much reach may interfere with piston and valve action. The exposed threads will collect deposits and the plug will be hard to remove. (b) A plug with too little reach will not extend into the cylinder far enough for proper combustion.

If the reach is too short, the spark is shielded, thus resulting in improper combustion of fuel in the cylinder. In this case the exposed threads in the cylinder head fill with deposits; consequently, it is difficult to install a plug with the proper reach until the threads are cleaned with a thread tap (Figure 84b).

IMPORTANCE OF PROPER MAINTENANCE

Any condition that reduces the flow of current through the spark plug and across the spark gap will affect the operation of the engine. The plug may then become fouled with **oil or lead deposits.** These deposits provide a path for part of the electric current to by-pass the spark gap. This condition may result in a weak spark or no spark. A cracked porcelain insulator will also cause a weak spark.

Here is what happens when a **spark plug wears out.** When a plug is new, the edges of the electrodes are sharp. A spark will jump the gap under cylinder pressure with as little as 10,000 volts. But, the spark gap widens as the engine is used.

Hot combustion gases and continuous electrical discharge both erode and corrode (wear away) electrodes until the edges become rounded and the spark gap widens. *The gap increases about .001 inch each 20 hours of engine operation.* After 100 hours of operation the gap may be wide enough to require 15,000 volts, or more, to jump the gap.

If your engine is new and the ignition system is in good condition, it will have little trouble producing 10,000 volts or even up to 20,000 volts. As the ignition system gets older, however, it may have trouble developing enough voltage to fire a worn plug. This makes spark-plug maintenance all the more important in older engines.

A plug may reach a stage where it cannot be cleaned and regapped properly. It should then be replaced with a new one.

A spark plug which does not function properly will increase fuel consumption, cause crankcase oil dilution, cause excessive deposits in the combustion chamber, cause hard starting, cause the engine to skip, and greatly reduce the efficiency of the engine.

TOOLS AND MATERIALS NEEDED

1. Spark-plug deep-sockets — 13/16" x 3/8" drive and 3/4" x 3/8" drive
2. T-handle — 3/8" drive
3. Torque wrench handle — 3/8" drive
4. Wire feeler gage
5. Ignition file
6. Pen knife
7. Wire brush
8. Small paint brush
9. Pan of petroleum solvent (mineral spirits, kerosene, or diesel fuel)

CHECKING THE SPARK PLUG FOR PROPER OPERATION

The spark-plug operational check consists of checking the intensity of the electric discharge being supplied to the spark plug from the magneto, or the ignition coil (battery ignition systems).

1. *Disconnect the spark-plug wire from the spark plug.*

   Pull friction connector straight up from plug (Figure 85).

2. *Loosen plug one or two turns, and then remove dirt (Figure 86a and b).*

   Use a **spark-plug socket wrench** that fits the plug. Do not use an open-end or box-end wrench or pliers. There is danger of cracking the porcelain or damaging the innerseal, which may cause severe leakage or burning. Hold the socket wrench so the socket is squarely over the plug when turning (Figure 86a). This helps protect the porcelain insulator

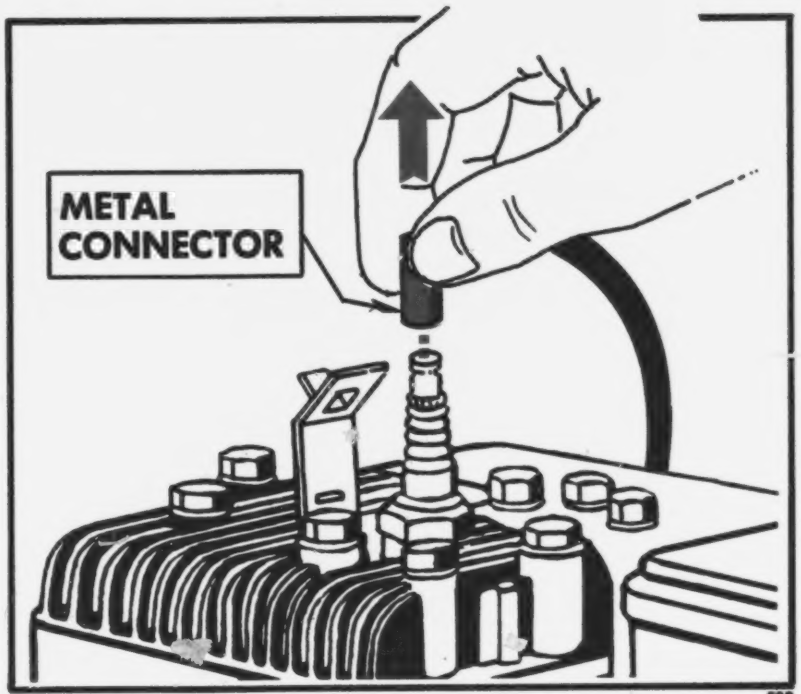


FIGURE 85. Grasp the metal connector on friction-held types and pull straight up, rather than pull on the wire insulation, when removing the spark-plug wire. This helps prevent loosening the connector from the wire end.

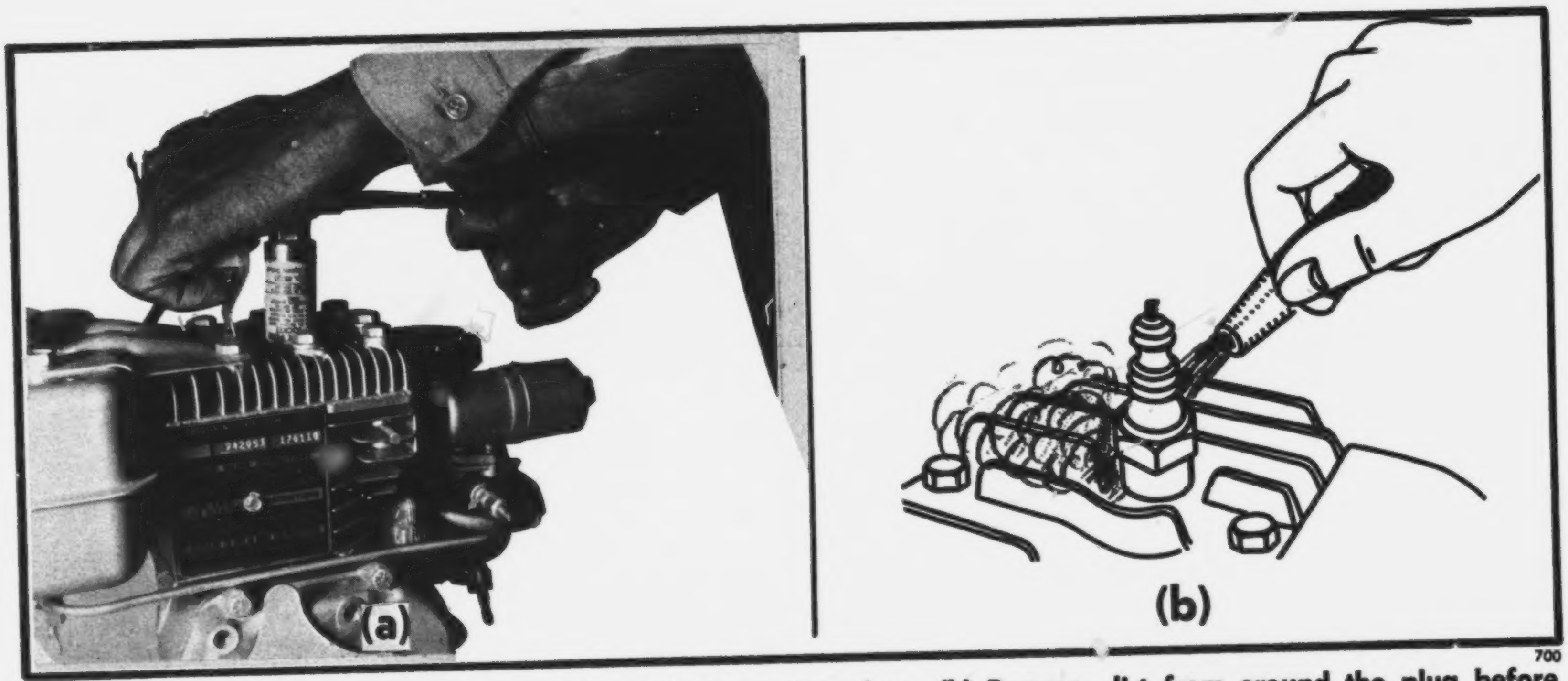


FIGURE 86. (a) Hold socket wrench straight while loosening plugs. (b) Remove dirt from around the plug before it is completely removed.

Remove dirt with an air blast (Figure 86b), small paint brush, or cloth to keep it from entering the cylinder. If you have an air hose equipped for inflating tires, press the hose connector against the top of the spark plug to trip the air-release valve.

If plug **threads are seized** to an aluminum head, apply petroleum solvent and rotate the plug back and forth until it is free. Otherwise, you may strip the threads.

3. *Remove the spark plug.*
4. *Remove gasket if it should remain on the cylinder head.*
5. *Reconnect the spark-plug wire.*
6. *Ground the spark plug to the engine (Figure 87).*

   Lay the spark plug on the cylinder head so the metal part is touching an unpainted surface of the engine. Paint will act as an insulator.
7. *Crank the engine one or two turns.*
8. *Observe the spark at the electrode.*

If the **spark plug is good** the spark should be a blue-orange color with multi-lines. There should be a sharp crackling sound. This action indicates the spark plug is good. If so, proceed to "Installing the Spark Plug," page 84.

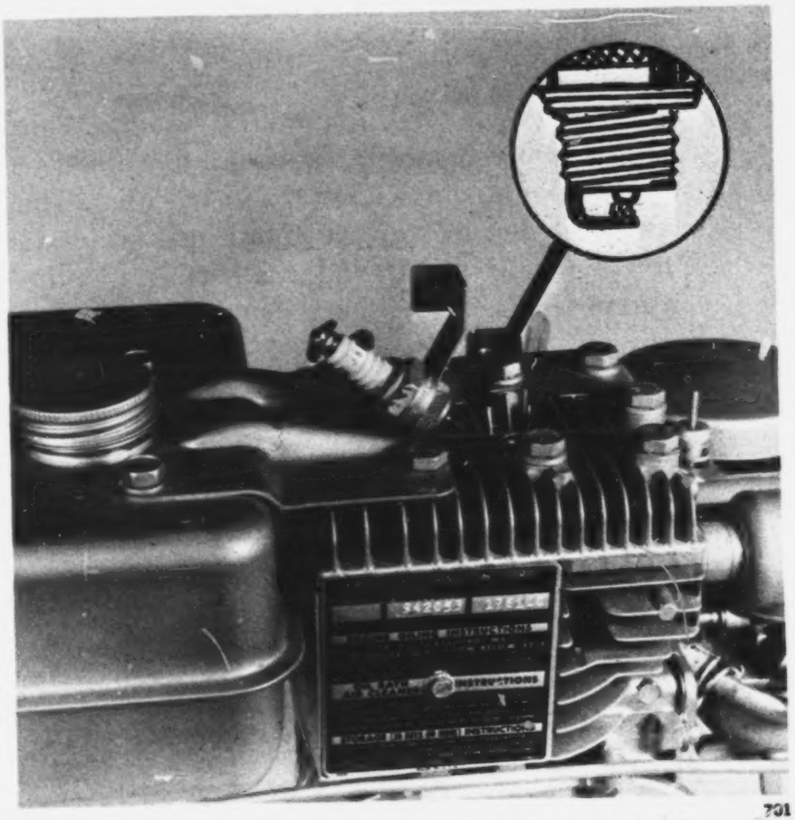
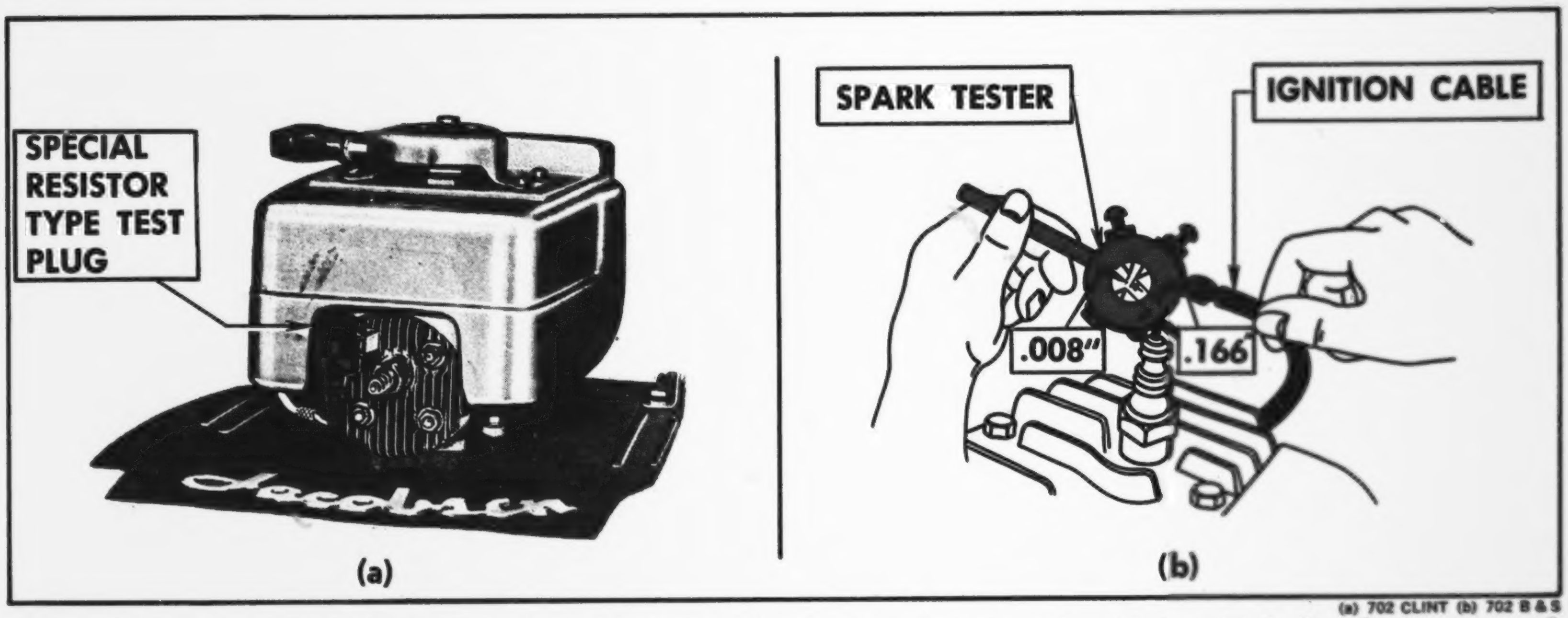


FIGURE 87. Checking the spark at the spark-plug electrode.



(a) 702 CLINT (b) 702 B & S

FIGURE 88. Two types of ignition testers. (a) A special test plug for testing the charge from the ignition system. The engine plug may be left in place. (b) An adjustable-gap spark tester. The third point is for the purpose of making the spark straight and solid so it can be seen more easily.

If there is no spark, or if the spark is weak, proceed to step 9. The trouble is either in the spark plug or in the ignition system.

9. *Disconnect the spark-plug wire from the spark plug.*

10. *Hold the end of the spark-plug wire approximately ¼ inch from the cylinder head, or use a spark tester.*

Available are ignition spark testers which give a more accurate check of the electrical charge being supplied to the spark plug. They are designed to provide conditions similar to those inside the cylinder when it is under compression.

Some are special spark plugs used only for this purpose (Figure 88a). They are designed to be clipped to the cylinder head for grounding.

Others are specially-made devices (Figure 88b). These are particularly useful if your engine has a resister-type spark plug. Such plugs have a resister in the center electrode to suppress radio noises. It shortens the duration of the spark, making it difficult to see when testing without this special tester.

To use this type of tester, hold it between the spark-plug terminal and the spark-plug wire and crank the engine.

11. *Crank the engine one or two turns.*

12. *Observe the spark between spark-plug wire and the cylinder head.*

If the spark is **blue-orange color,** the ignition system is good The trouble is in the spark plug. Proceed to the next heading "Inspecting and Servicing the Spark Plug."

If there is **little or no spark,** the trouble is in the ignition system. Refer to "Maintaining and Repairing Ignition Systems," Volume II.

INSPECTING AND SERVICING THE SPARK PLUG

Most manufacturers recommend removing, inspecting, cleaning, and regapping a spark plug after every *100 hours of operation,* whether you suspect trouble or not. A good time for servicing the spark

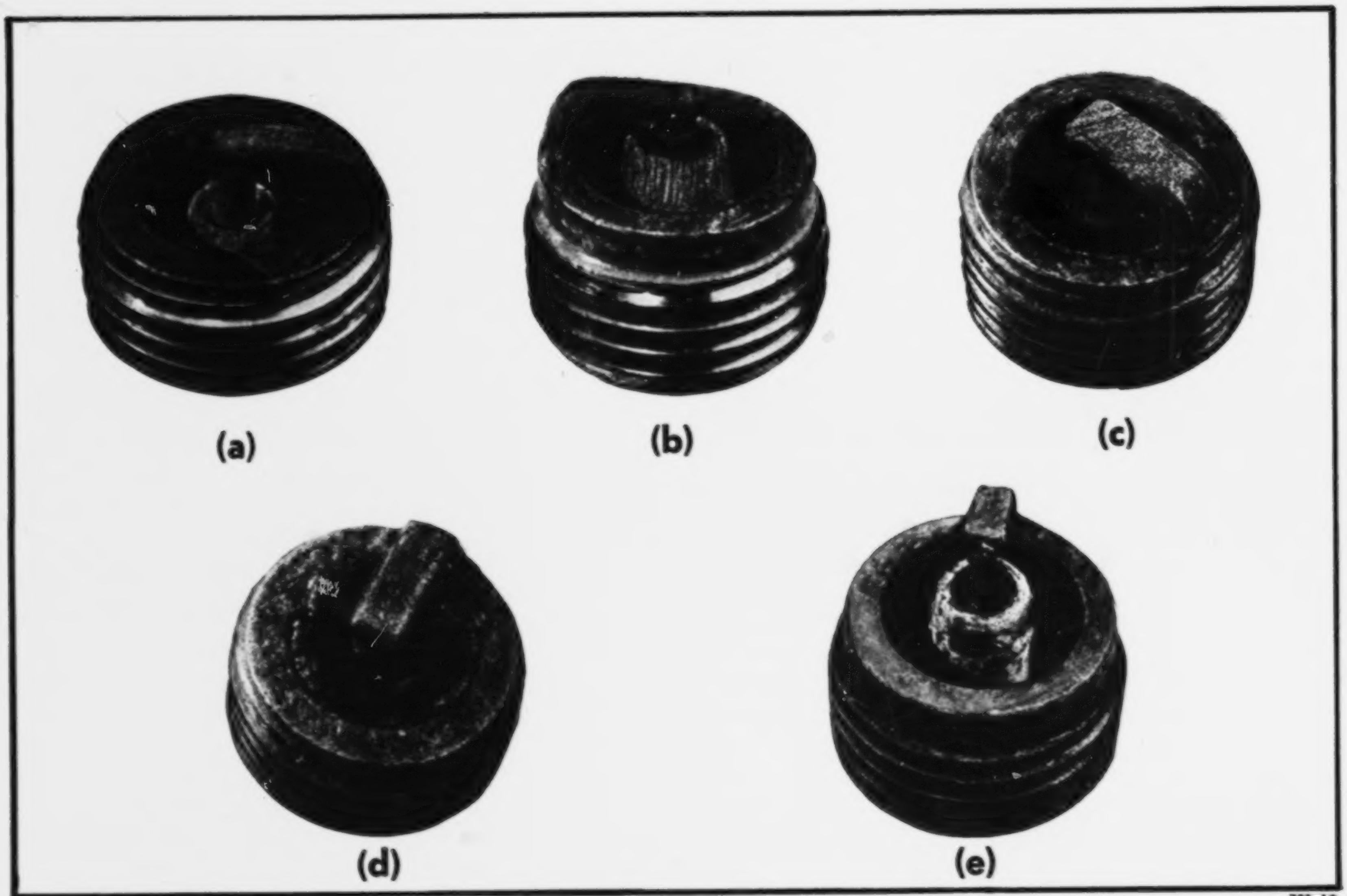


FIGURE 89. (a) Brown to grayish-tan deposits and slight electrode wear indicate normal wear. (b) Electrodes eroded and insulator pitted indicate plug is worn out. (c) Soft fluffy carbon deposits indicate a rich fuel mixture or ignition system trouble. (d) Wet oily caked deposits indicate excessive oil consumption or too cold a plug for conditions. (e) Ashy-looking insulator or blisters on porcelain indicate plug is running hot. Check heat range of plug and check gasket condition.

plug is at the beginning of each season. This may prevent trouble later when you have less time to work on the engine.

Proceed as follows:

1. *Check the condition of the plug.*

   Figures 89 and 90 show different conditions you may find. Plugs that are worn (Figure 89a) should be replaced with new ones of the type and size recommended for your engine. Check your operator's manual or see your dealer to make sure of this.

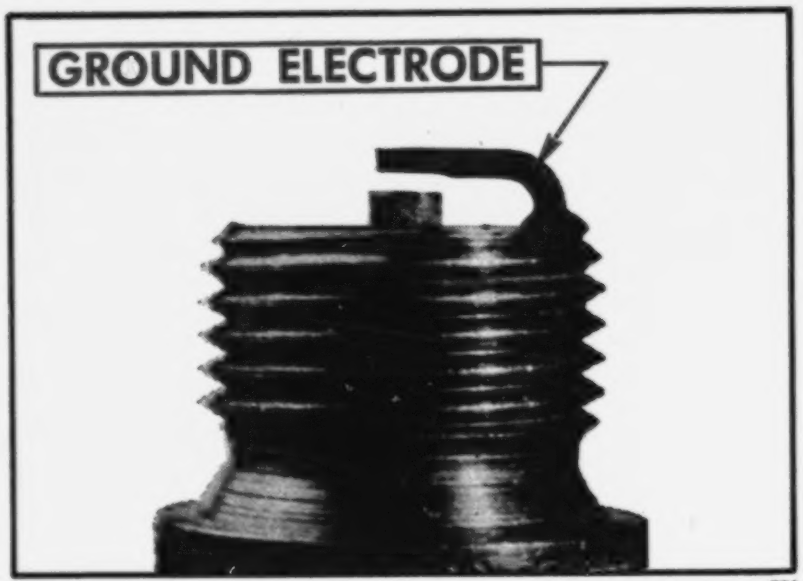


FIGURE 90. "Dishing" of ground electrode caused by reverse coil polarity—primary leads to ignition coil have been reversed (battery-ignition systems.)

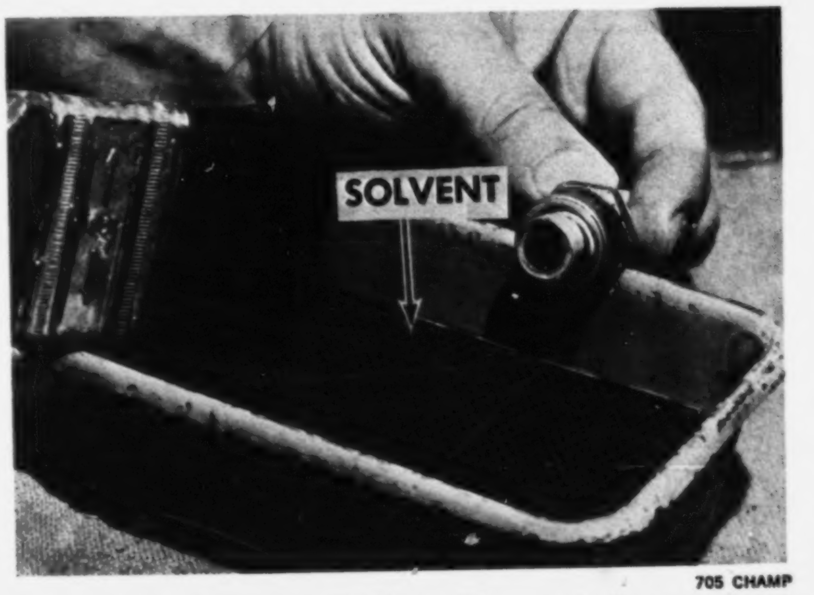


FIGURE 91. Remove oil film with a petroleum solvent.

2. *Remove oily deposits from plugs (Figure 91)*

   Put plugs in a pan of solvent, such as kerosene, distillate, or diesel fuel, to remove oily film from porcelain body. Remove solvent with a clean cloth.

3. *Clean threads with a wire brush (Figure 92)*

   This cleaning is important for removing dirt so the plug will not bind when reinstalled.

   Do not brush the insulator. It will leave a metallic film which may provide an electrical short to ground.

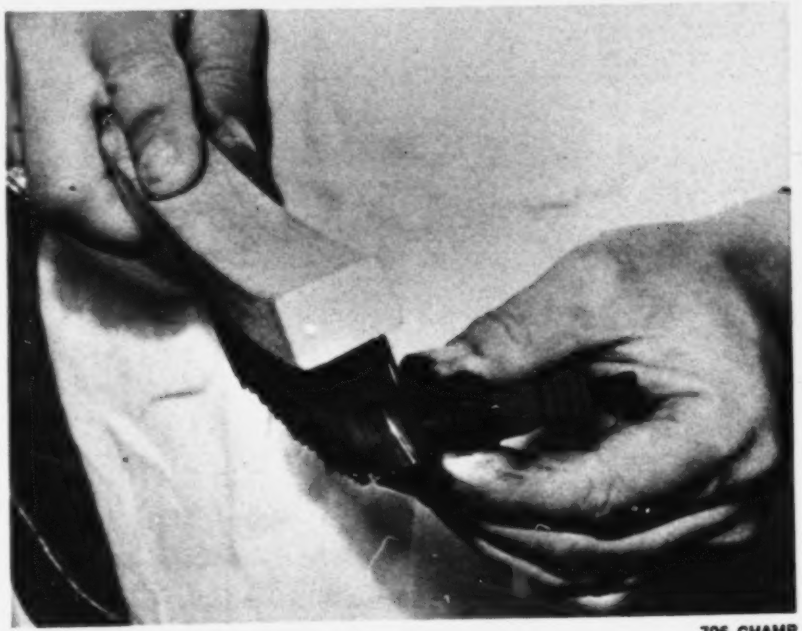


FIGURE 92. Clean spark-plug threads with a wire brush.

4. *Remove deposits from plugs.*

   Use a small bladed knife (Figure 93a) for removing hard deposits. Even with sand blasting (Figure 93b), it is well to finish removing any hard deposits with a small blade. Watch that you do not damage the insulator around the center electrode.

   A sand-blast machine (Figure 93b) does an excellent job of cleaning a spark plug, but *some manufacturers void the warranty* on an engine if a sand blast is used to clean

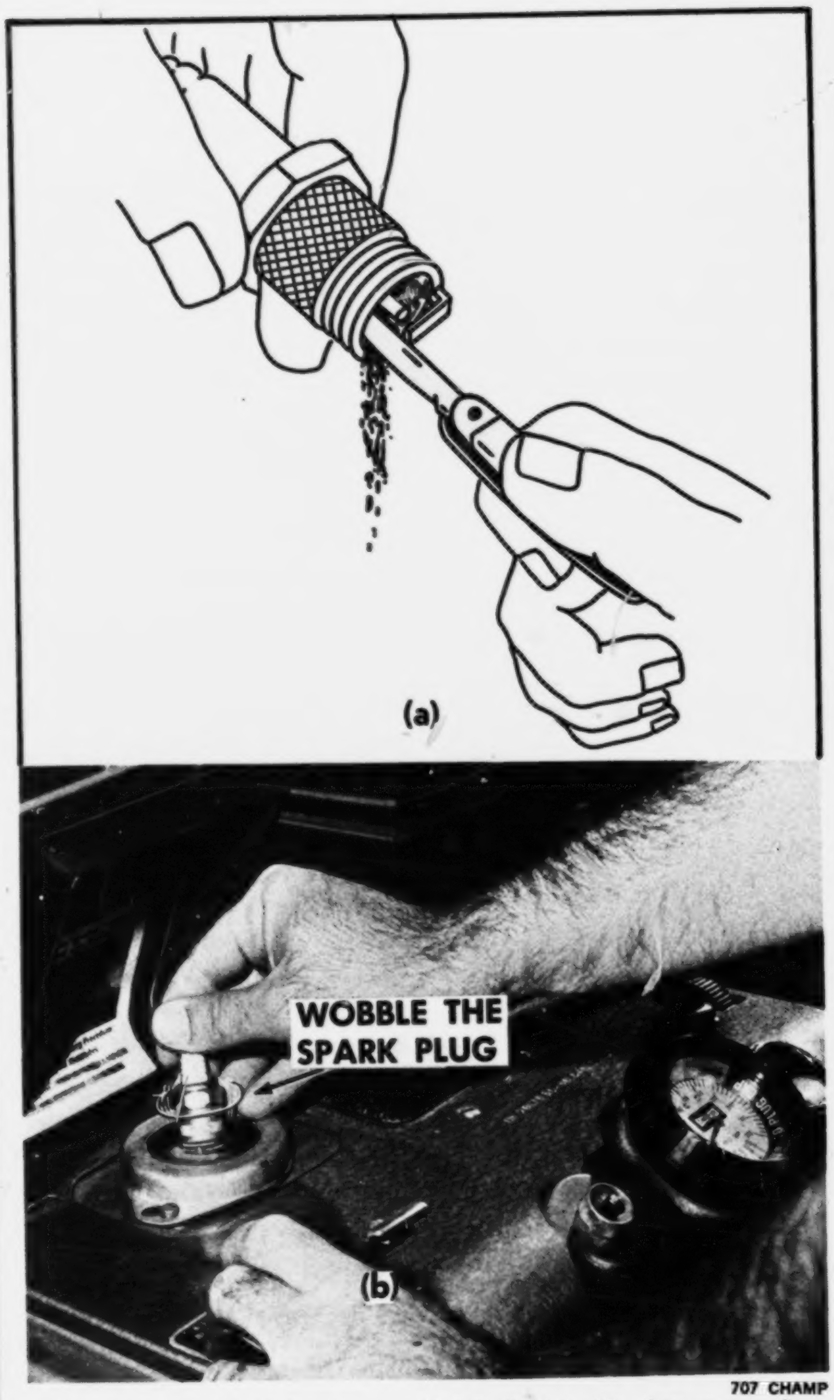
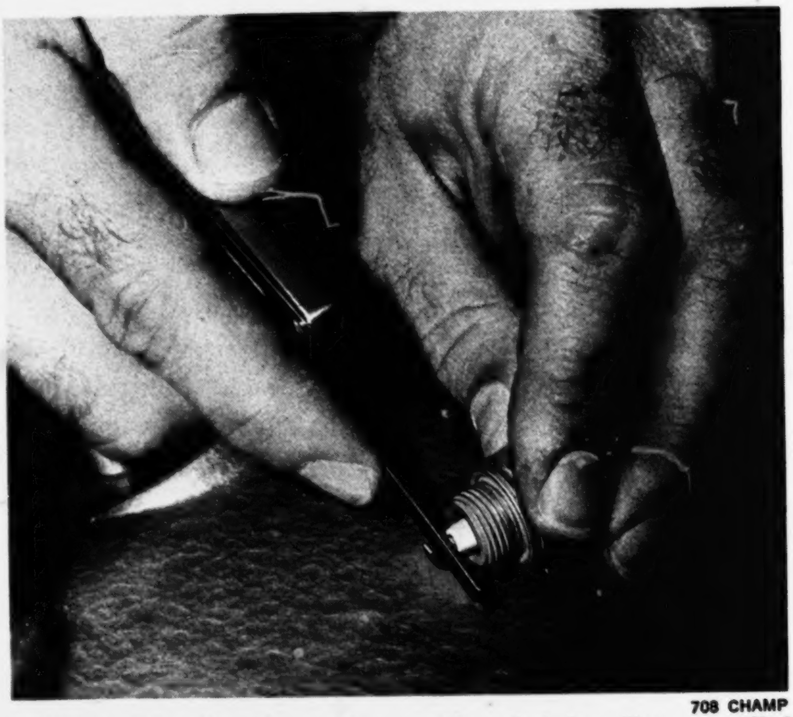


FIGURE 93. (a) Using a small bladed knife for removing hard deposits. (b) A sand-blast type of cleaner.



708 CHAMP

FIGURE 94. File electrodes until a bright, flat, parallel surface is produced.

the spark plug. They say it is practically impossible to remove all the abrasive materials after cleaning. There is much risk of internal damage to the engine caused by sand particles that may remain in the plug after cleaning, enter the cylinder during engine operation, and cause rapid wear.

If you use a sand blast, be sure to clean the spark plug thoroughly to remove any loose sand or metal.

5. *Blow loose materials from plug with compressed air.*

   This is important to get rid of any remaining particles.

6. *Bend the ground electrode (not the center electrode) away from the central electrode.* Bend enough to allow room for a thin (ignition point) file.

7. *File electrodes on plug until both have flat surfaces (Figure 94).*

   The flat surfaces help assure against misfiring.

   About 25 to 40 per cent less voltage is required to fire a spark plug with sharp edges on the central electrode than one with a round end.

   File end of center electrode until it is flat (Figure 94). Follow the same procedure with the eroded surface on the ground electrode. Remove as little material as possible.

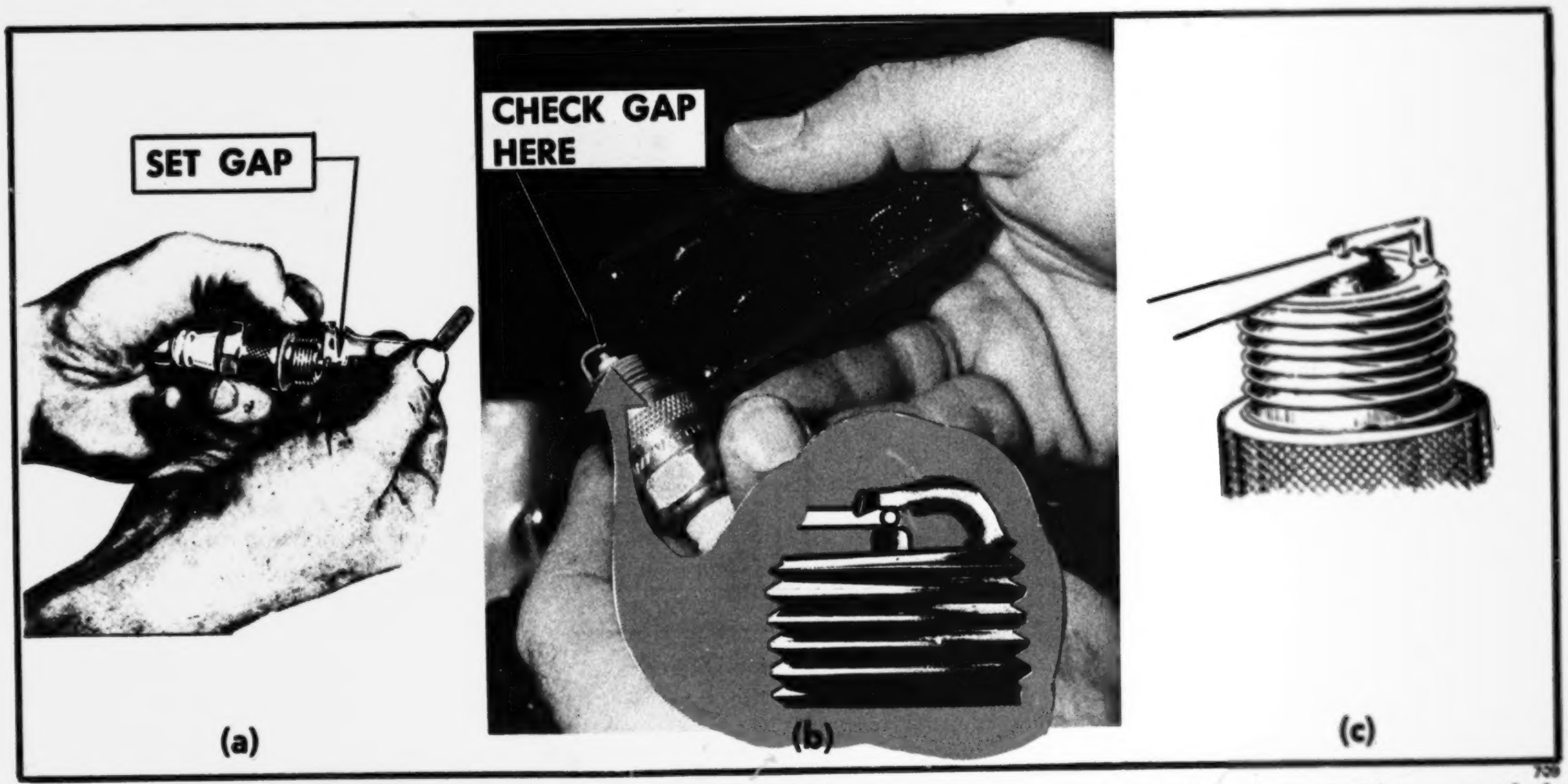


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FIGURE 95. (a) A gap setter is used to bend the ground electrode for adjusting the gap. (b) A wire feeler gage tends to follow the round contour that may remain after filing the electrodes. (c) A flat gage bridges rounded surfaces, thus resulting in a gap that is too wide.

8. *Bend the ground electrode back into its original position.*

9. *Determine proper spark-gap spacing for your engine.*

   Check your operator's manual or one of the charts issued by spark-plug companies.

   Most plugs are set on .025 inch. The range is from .020" to .040". Radio-shielded plugs are set at .020". Very few plugs are set at .040".

10. *Regap plug (Figure 95).*

    Make all adjustments by bending the ground electrode as shown in Figure 95a. This is done by trial. Check with a feeler gage of the proper thickness until you get the proper gap (Figure 95b).

    A flat feeler gage can be used for new plugs, but for used plugs it is difficult to remove completely the "cup" in the ground electrode. A flat feeler gage tends to bridge over the cup — if not filed away — which results in your setting the gap too wide (Figure 95c). Use a wire feeler gage to avoid this difficulty.

INSTALLING THE SPARK PLUG

1. *Replace plug and tighten with fingers.*

   Be sure to put a *new gasket* on the plug (Figure 96). The only plugs that do not required gaskets are ones with tapered seats. Without a gasket a spark plug may extend into the combustion chamber far enough to become damaged.

   It is best to use a new gasket to insure proper seating. If you do not have one, check the condition of your old one. If it has not been flattened by too much plug tightening, it may still be usable.

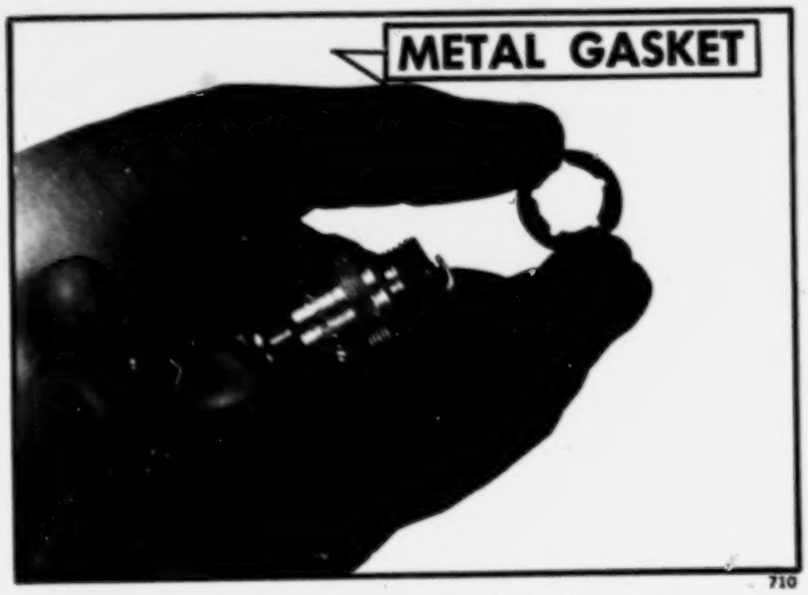


FIGURE 96. Place a gasket on the plug before reinstalling.

Figure 97a shows a gasket that has been flattened from over-tightening.

If you can not seat the plug in the cylinder

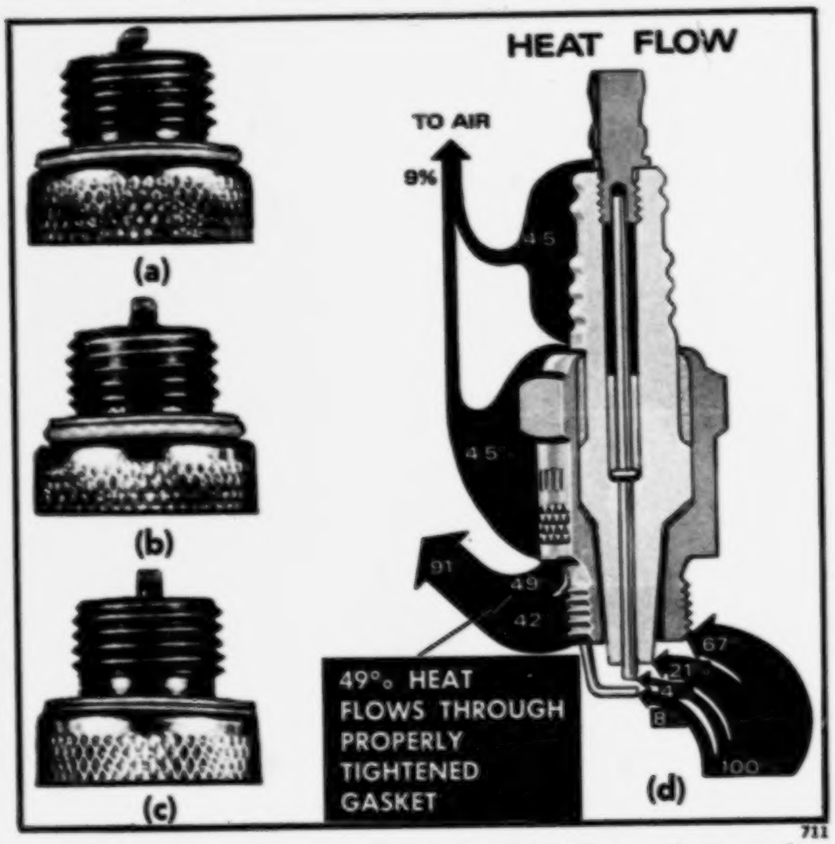


FIGURE 97. (a) When a spark plug is tightened properly, the gasket will be crushed to about 2/3 of its original thickness. (b) If not tightened enough, it may show little or no crushing. (c) If over tightened, it has a definite flattened appearance. (d) Heat moves readily from a properly tightened plug through the gasket to the cooling fins.

TABLE III. TORQUE RECOMMENDED FOR TIGHTENING SPARK PLUGS

SPARK-PLUG THREAD SIZES	TORQUE WRENCH*		WITHOUT TORQUE WRENCH Engine Cool
	(Cast-Iron Head)	(Alum. Head)	
(Approx. Size in inches)	(ft. — lbs.)	(ft. — lbs.)	Turns with wrench (Beyond finger tight)
10mm (3/8 +)	12 — 15	10 — 11	3/4 to 1
14mm (9/16 -)	25 — 30	22 — 27	1/2
18mm (11/16 +)	30 — 40	25 — 35	1/2 to 3/4

*Combined recommendations of two spark-plug manufacturers.

head by hand, remove it and wipe the threads in the cylinder head with a clean cloth.

2. *Completely tighten the plug with a spark-plug socket wrench.*

   If you use a torque wrench, check your operator's manual to determine how much torque should be applied; or if it is not stated, Table III will serve as a guide.

   If you *do not have a torque wrench,* give the plug an additional turn as indicated under the heading of "Turns with wrench," Table III, which should tighten the plug adequately on the gasket.

   If the **plug is not tightened properly** on the gasket, heat will build up and cause the plug to overheat. If **properly seated,** the gasket is compressed enough so that heat will travel readily from the plug to the cooling fins.

   If the **plug is to tight,** it will be distorted. The gap between the electrodes will change. The added stress may also break the porcelain.

3. *Check condition of connections and insulation on spark-plug wire when reattaching wire to spark plug.*

4. *Check polarity of spark at spark plug on a battery-ignition system.*

   If ground electrode on spark plug is "cupped," the polarity is wrong—from 5 to 45 per cent more voltage may be required to fire the plug. Here is the reason why. Electrons (a spark) jump more readily from a hot surface to a cool one than from cool to hot. Since the center electrode of the spark plug is hotter than the ground electrode, it is important that the primary circuit to the ignition coil be connected so the spark jumps from the center terminal.

   To check polarity, hold the metal connector about ¼ inch from the spark-plug terminal (Figure 98). Insert pencil as shown.

   If the spark feathers and has a slight orange tinge on the plug side, polarity is correct.

   If the spark feathers on the connector side, polarity is reversed. Correct by interchanging primary wire connections on the ignition coil.

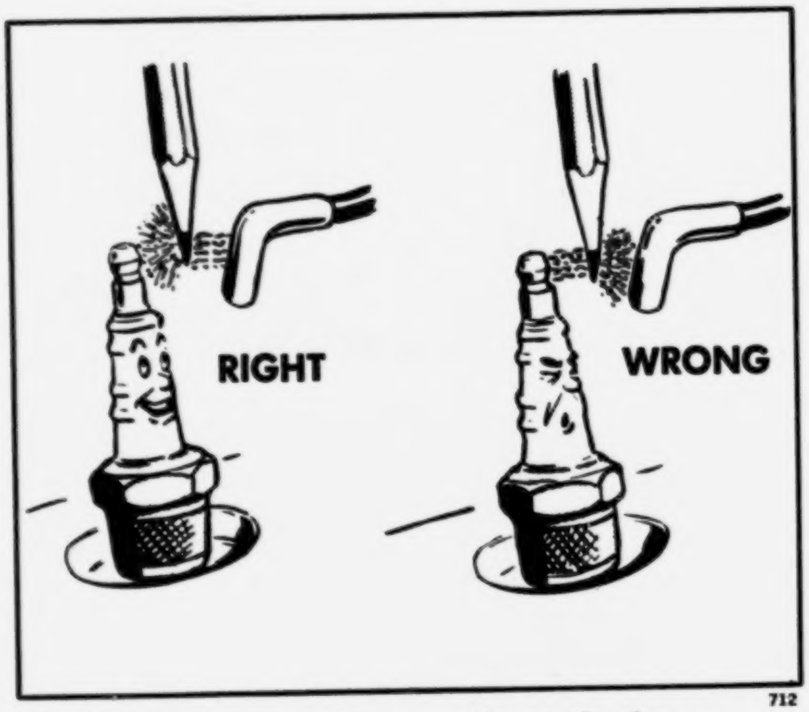
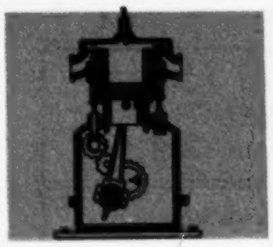
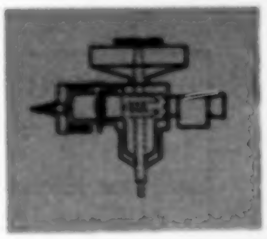


FIGURE 98. Testing polarity at the spark plug.



I. CHECKING AND ADJUSTING CARBURETORS



The function of the carburetor is threefold:

- It breaks up (atomizes) the fuel into a fine spray and mixes it with air to make a mixture that will burn readily.
- It regulates the ratio of fuel to air.
- It regulates the amount of the fuel-air mixture going into the combustion chamber.

The **ratio of fuel to air** is controlled by adjustable needle valves. Adjustments are provided so you can select the proper mixture for the conditions under which you operate your engine. They are usually set at the factory and rechecked by your dealer when you purchase the engine.

As you use the engine, normal wear and vibration cause the carburetor valve openings to change. The carburetor is then out of adjustment. Operating your engine with the carburetor out of adjustment may result in high fuel consumption and loss of power.

Excessive fuel consumption is not usually important in the operation of a small gasoline engine. Even the loss of 10 to 20 per cent of the engine horsepower is not noticeable on many applications. The harmful results come from operating the engine with the carburetor out of adjustment.

Too lean a fuel-air mixture may result in hard starting, overheating, pre-ignition and valve burning.

Too rich a fuel-air mixture may result in excessive fuel consumption, carbon build up in the cylinder and cause pre-ignition.

To avoid such difficulties you need to know the principles of carburetor operation and how to adjust it for satisfactory engine operation. This information is given under the following headings:

1. Principles of operation.
2. Types of carburetors and how they work.
3. Tools and materials needed.
4. Checking the carburetor for proper operation.
5. Preparing for carburetor adjustment.
6. Adjusting the carburetor choke valve.
7. Adjusting the high-speed, load valve.
8. Adjusting the idling valve.
9. Adjusting the idle-speed stop screw.

PRINCIPLES OF OPERATION

As mentioned earlier, one of the main functions of a carburetor is to make a spray of the fuel (atomize it) and mix it with the incoming air. Here is how that is accomplished.

- As the piston moves down (on the intake stroke), *a partial vacuum is developed in the cylinder* (Figure 99).

  On **4-cycle engines,** during the intake stroke the intake valve is open and the exhaust valve closed. See Figure 5, page 12 on **2-cycle engines,** the low pressure is created in the crankcase on each upward motion of the piston. See Figure 6, page 14.
- *Atmospheric pressure pushes air* through the

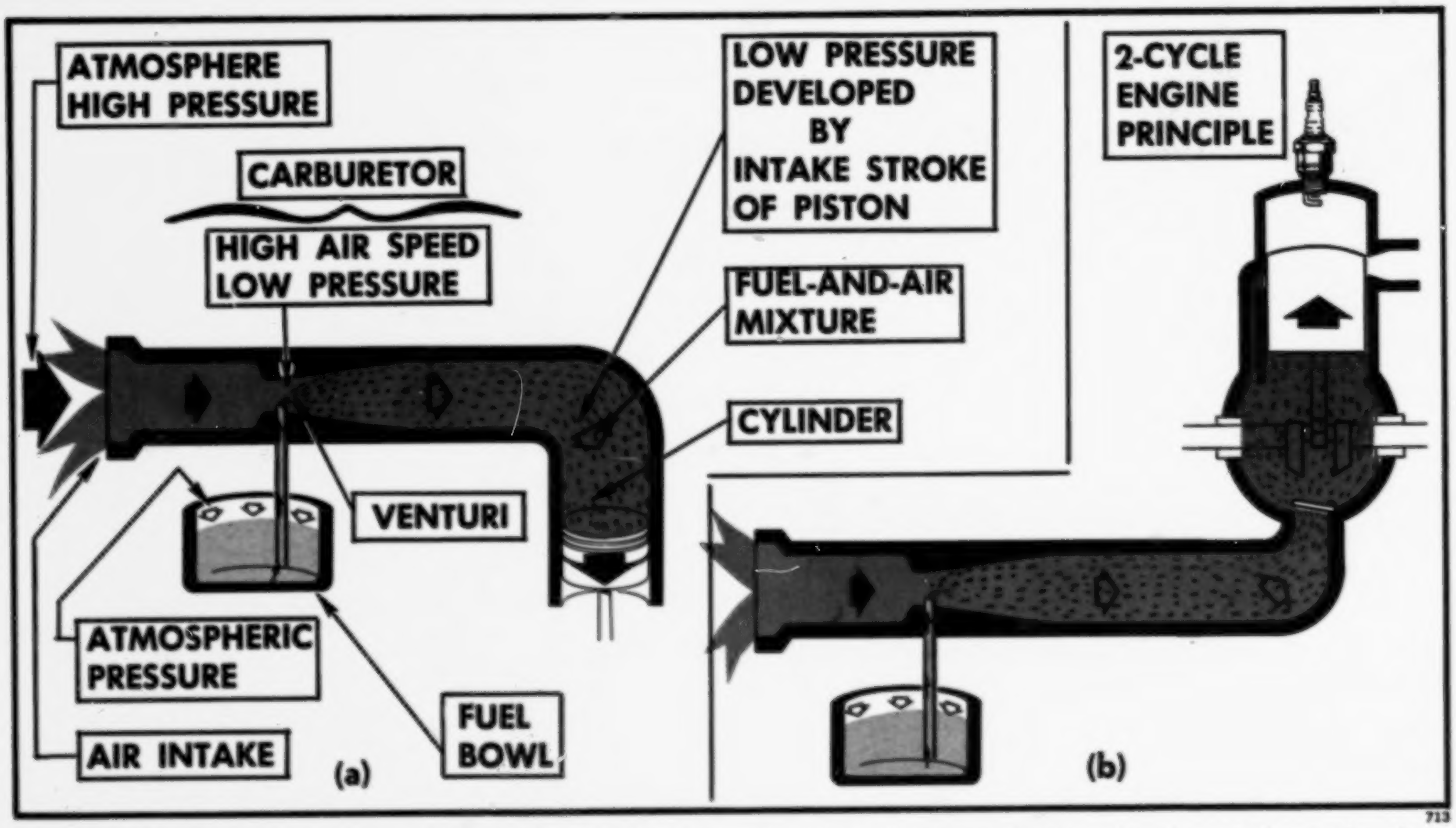

ATMOSPHERE HIGH PRESSURE
CARBURETOR
HIGH AIR SPEED LOW PRESSURE
LOW PRESSURE DEVELOPED BY INTAKE STROKE OF PISTON
FUEL-AND-AIR MIXTURE
CYLINDER
VENTURI
ATMOSPHERIC PRESSURE
FUEL BOWL
AIR INTAKE
(a)
2-CYCLE ENGINE PRINCIPLE
(b)
713

FIGURE 99. Basic operating principle of a carburetor. Air is drawn through the carburetor air intake by the partial vacuum created by (a) the downward stroke of the piston on 4-cycle engines, or (b) the upward stroke of the piston on 2-cycle engines. Low pressure at the venturi causes fuel to be forced from the fuel bowl to the venturi and into the air stream by atmospheric pressure where it is atomized and mixed with the air.

carburetor air intake to equalize the pressure (Figure 99).

- The *air speed increases* in the venturi — the narrow passage in the air-intake tube. Since the same volume of air must pass through the narrow passage that passes through the section that is not restricted, the speed must increase at that point. As air speed increases, its pressure is lowered. This is according to Bernoulli's scientific principle.

- When the pressure lowers in the venturi, *atmospheric pressure* in the fuel bowl *pushes fuel through the pipe to the venturi and into the air stream.*

- The *speed* of the air in the venturi and the air *turbulence* past the venturi atomize the fuel and mix the tiny droplets with the air.

Once the air and fuel are mixed, the next job of the carburetor is to provide a means whereby the amount of mixture that enters the engine cylinder can be controlled. Here is how that is accomplished

- A **butterfly (throttle) valve** in the manifold controls the fuel and air (Figure 100). If you want your engine to *run fast*, open the butterfly (throttle) valve. The more fuel and air going into the engine, the faster it runs.

  If you want your engine to *run slowly*, close the throttle valve. The throttle valve does not change the ratio of fuel to air. It simply regulates the amount of fuel-air mixture going into the engine.

- A **"choke" valve** is used to aid in *cold starting* (Figure 101).

  It helps provide for *better vaporization of the fuel* and also provides for *more fuel-to-air* (a richer mixture). (Only vaporized gasoline will burn, and the richer mixture provides for more gasoline to be vaporized.)

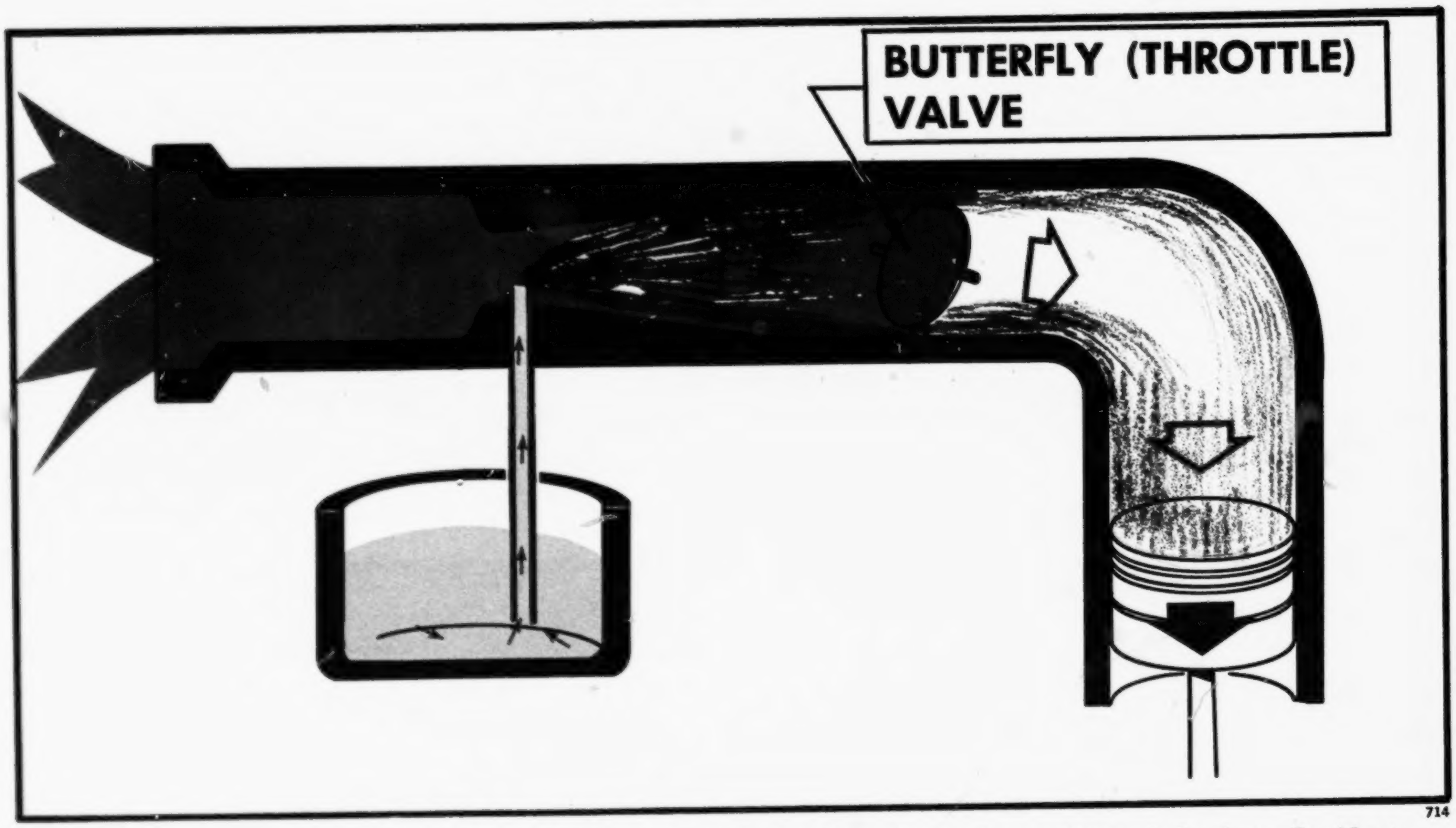

BUTTERFLY (THROTTLE) VALVE
714

FIGURE 100. The amount of fuel and air going into the cylinder depends on the position of the butterfly (throttle) valve.

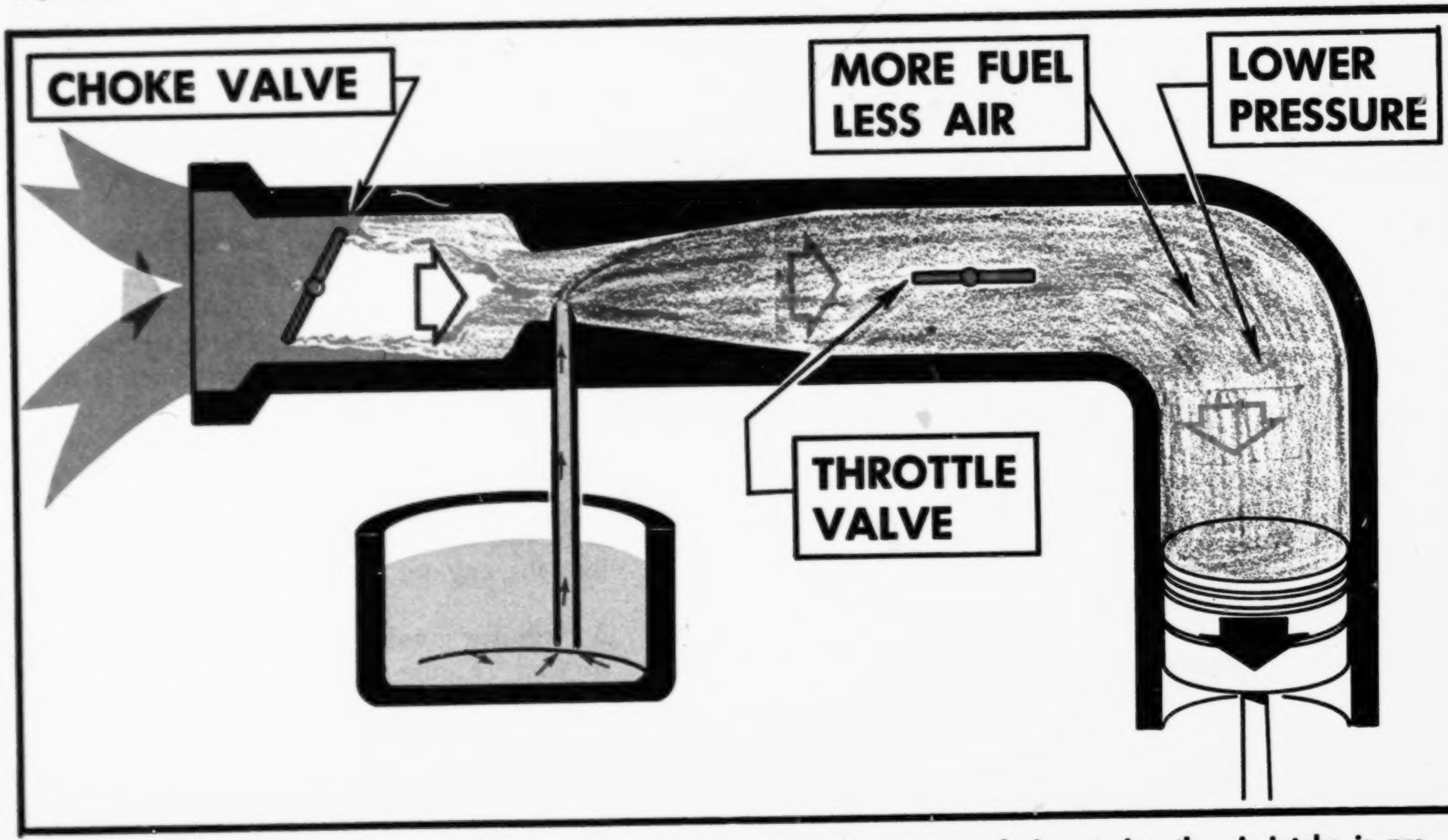

CHOKE VALVE
MORE FUEL LESS AIR
LOWER PRESSURE
THROTTLE VALVE
715

FIGURE 101. For cold starting, a choke valve which restricts the amount of air entering the air intake is provided. Fuel-air mixture becomes richer.

The choke valve is similar to the butterfly (throttle) valve—except it is placed on the air-intake side of the carburetor. When the choke is closed, the air going into the carburetor is restricted. The pressure inside the carburetor and cylinder is further reduced from that which was caused by the downward stroke of the piston. *The lower pressure increases the vaporization of the fuel.*

The richer fuel-air mixture is provided by the lower pressure created in the venturi section of the carburetor. The lower the pressure, the more fuel is forced into the fuel intake system by atmospheric pressure.

If all engines operated at one speed, with a constant load and with all other conditions being the same, the type of carburetor you have just studied would be adequate. These conditions, however, vary even from moment to moment with the same engine. This means that certain provisions and adjustments must be added to the carburetor to make your engine operate satisfactorily.

When the engine is operating, different ratios of fuel-to-air are needed to provide a more desirable mixture to meet different load and speed demands. Also, different natural operating conditions affect the ratio of fuel-to-air needed, such as operating at high altitudes compared to low altitudes, humid air conditions compared to dry air conditions and high temperatures compared to low temperatures.

Following are examples of ideal fuel-air ratios for different operating conditions.

Operating condition	Ratio of lbs. air* required per lb. of fuel
Cold starting	1 : 7
Accelerating	1 : 9
Idling	1 : 11
Part throttle—loaded	1 : 15
Full throttle—loaded	1 : 13.5

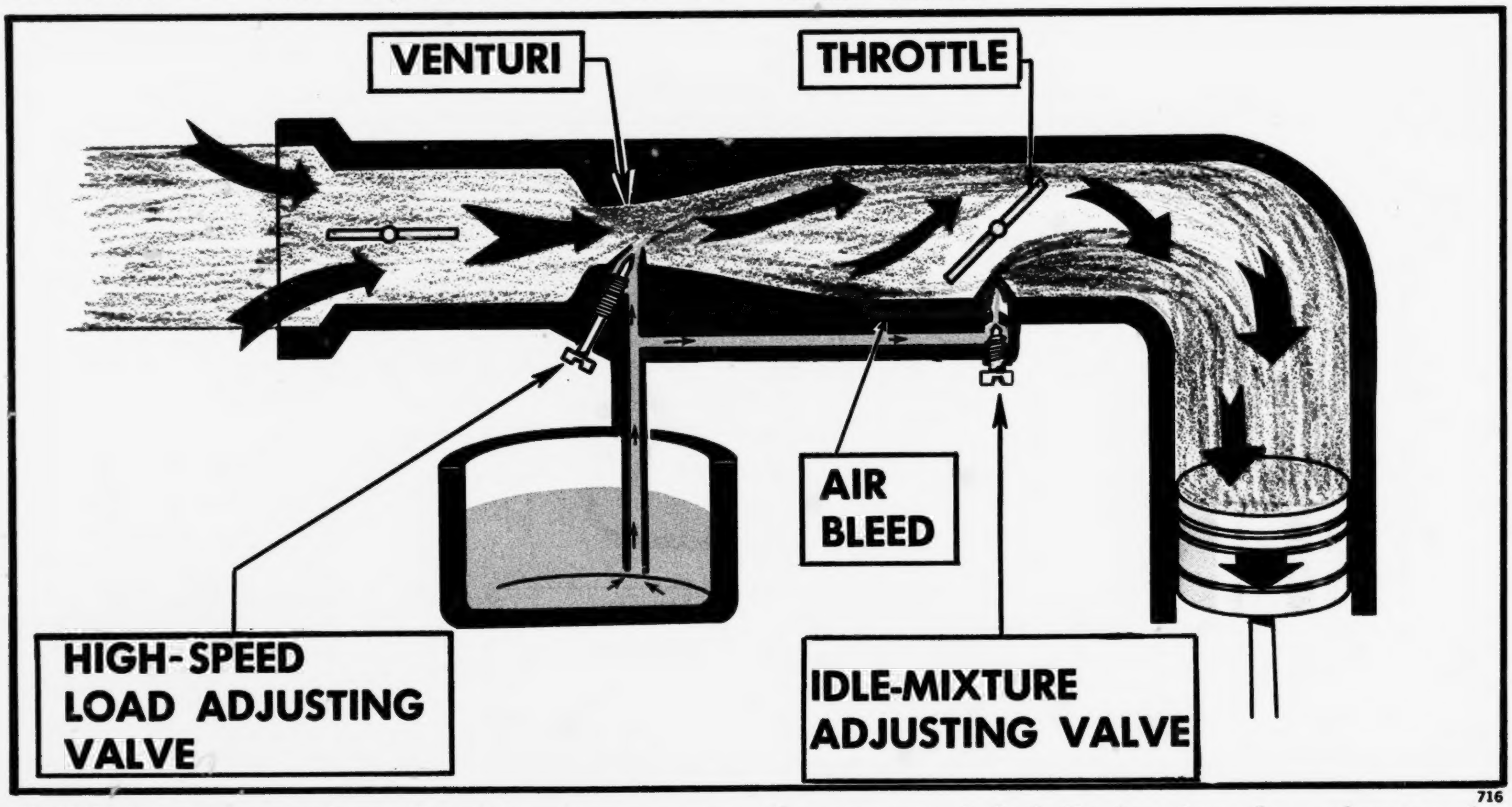


FIGURE 102. For operation, adjustable valves are provided for regulating the fuel-air ratio entering the intake manifold. The size of the valve openings determines the amount of fuel flowing into the carburetor air stream.

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*A common way of stating the proportion of fuel to air is by volume. One gallon of fuel requires about 8,000 gallons of air for combustion in an engine. Here, weights of fuel and air are used in place of volume as a more practical means of expressing the fuel-air ratio. Air weighs about 1.22 ounces per cubic foot under standard conditions.

When the engine is not functioning properly, you can make further adjustments which will cause the fuel-air mixture to be richer or leaner. Most carburetors have two adjusting valves which control the amount of fuel being mixed with the air (Figure 102): (1) an *idle-mixture valve* and (2) a *high-speed load valve.*

The **idle-mixture valve** is used primarily for supplying fuel to the engine when it is idling. It is positioned on the engine side of the butterfly valve, so that the fuel-air mixture will continue to flow when the throttle is closed. An air bleed (Figure 102) provides for air during idling when the throttle is closed.

The **high-speed, load valve** supplies the fuel for other operating conditions.

On most carburetors both valves are used to adjust the amount of liquid fuel being fed into the air stream. This is what determines the fuel-air ratio. The idling jet is adjusted while the engine is idling and the load jet while the engine is under load or at least above idling speed.

TYPES OF CARBURETORS AND HOW THEY WORK

There are *three types of carburetors* used on small engines:

- The *float-type* (Figure 103).
- The *suction-lift type* (Figure 110).
- The *diaphragm type* (Figure 113).

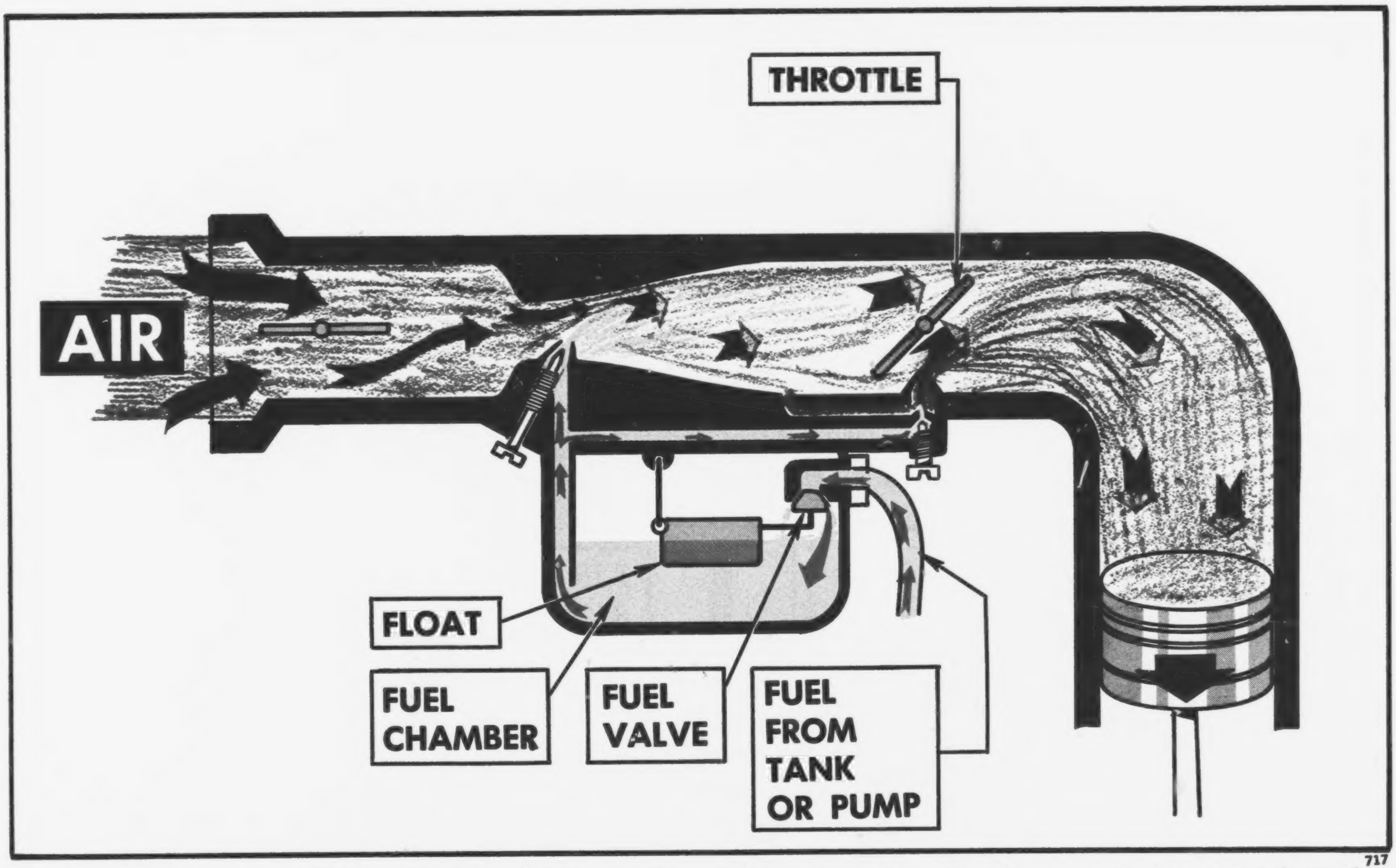

FIGURE 103. A schematic drawing of a float-type carburetor. The purpose of the float is to maintain a constant level of fuel in the carburetor. When the fuel level in the fuel chamber drops, so does the float. The valve opens, thus allowing more fuel to enter from the fuel tank or fuel pump. When the incoming fuel reaches a certain level, the float rises and the float valve closes, thus maintaining a constant level of fuel.

Each operates on the same basic principles; but when you first look at them, you may think they are quite different.

FLOAT-TYPE CARBURETOR

Float-type carburetors are so called because the fuel level in the fuel chamber is maintained by a float-controlled valve (Figure 103). There is, however, more to the float carburetor than this. Included are additional features which provide for adjustment and regulation of the fuel-air ratio to meet different operating conditions.

The carburetor shown in Figure 104 is for a constant speed and constant-load operation. It includes the principles shown in Figure 103 but with an adjusting needle valve for regulating the fuel-air mixture. This carburetor is similar to commercial designs.

When a *sudden load* or acceleration is demanded of the engine, a richer mixture (more fuel-air ratio) is required (Figure 104b). The *accelerating well* provides a ready source of fuel for this need. The accelerating well is a compartment that surrounds the lower part of the fuel discharge nozzle and remains full of fuel while the engine is operating under normal load. When there is a sudden demand for power, the governor* opens the throttle valve and air moves past the nozzle much faster, thus picking up additional fuel. This action causes a lower air pressure at the nozzle tip than at the air bleed. This pressure difference forces fuel from the accelerating well through the holes into the lower part of the nozzle assembly and out through the nozzle tip, thus supplying a richer fuel mixture to the engine.

Without the accelerating well an adequate flow of fuel would not be maintained from the float chamber and the engine would miss during acceleration.

An orifice (a small opening) in the air bleed restricts the air and prevents the mixture from becoming too lean.

During and immediately after the power surge, the accelerating well is refilled from the float chamber.

The *high-speed valve* automatically provides a fuel-air ratio adjustment after acceleration. If the heavy load continues, the fuel-air mixture need not continue to be so rich. With the accelerating well empty, the air passes through the air bleed opening into the accelerating well and out through the nozzle along with the regular fuel supply, thus reducing the richness of the mixture.

When idling (Figure 104c), the throttle valve is closed. Air flow through the venturi is not sufficient to reduce the pressure enough to draw fuel from the float chamber. An additional fuel outlet is provided, past the throttle valve (between the throttle valve and the engine). This outlet supplies fuel (at the proper mixture) to the engine for idling. The size of this discharge port determines the fuel flow. Note in Figure 104c that fuel passes from the accelerating well up through a special passage and is mixed with air where it joins the passage from the idle-air bleed. The mixture then passes into the intake manifold through the upper discharge port above the throttle valve. The throttle valve can be completely closed, but your engine will continue to run because of this provision in the carburetor. Note that the air also enters through the lower discharge port with the throttle valve completely closed to prevent an overly rich mixture.

As the throttle valve is opened, the lower discharge port also becomes exposed to low pressure in the intake manifold. Through it an additional supply of fuel-air mixture is delivered to the engine to prevent a lean mixture when the throttle is slightly open. Opening the throttle further causes the main fuel nozzle to supply fuel by the venturi action. It continues to do so on an increasing scale as the throttle valve opens.

Other features on float-type carburetors with which you should be familiar are the **pressure equalizing arrangement** to the float chamber and the choke valve. Most float-type carburetors have a *pressure-equalizing connection* (Figure 104d). This is a passage that connects at the carburetor air inlet and extends around the venturi to the float chamber. This connection keeps air pressure in the float chamber the same as that in the carburetor. This is an important provision because the air cleaner causes a slight drop in the air pressure entering the carburetor. Without the pressure equalizing connection, fuel in the float chamber

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*Refer to "Maintaining and Repairing Governors," Volume II.

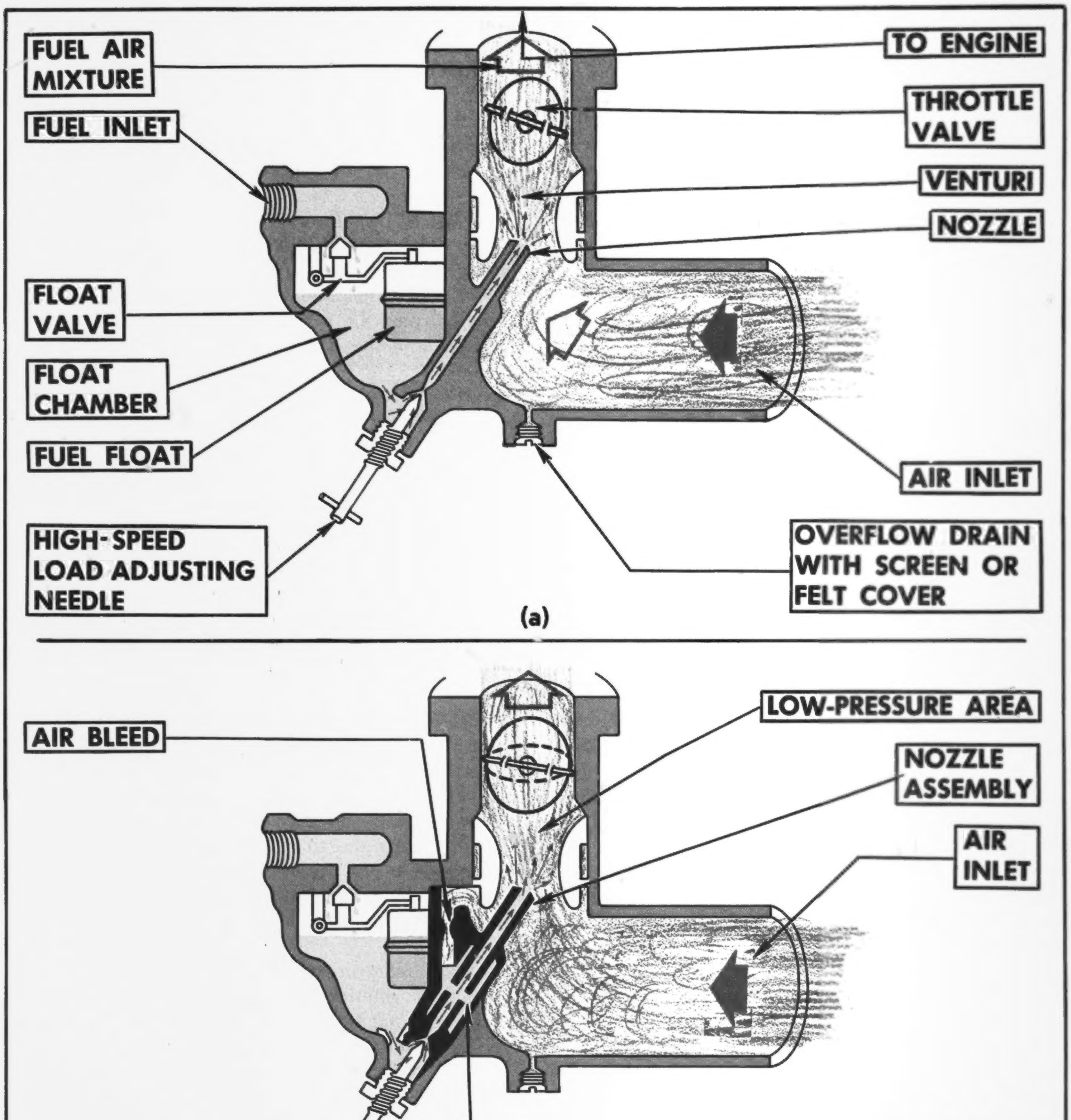
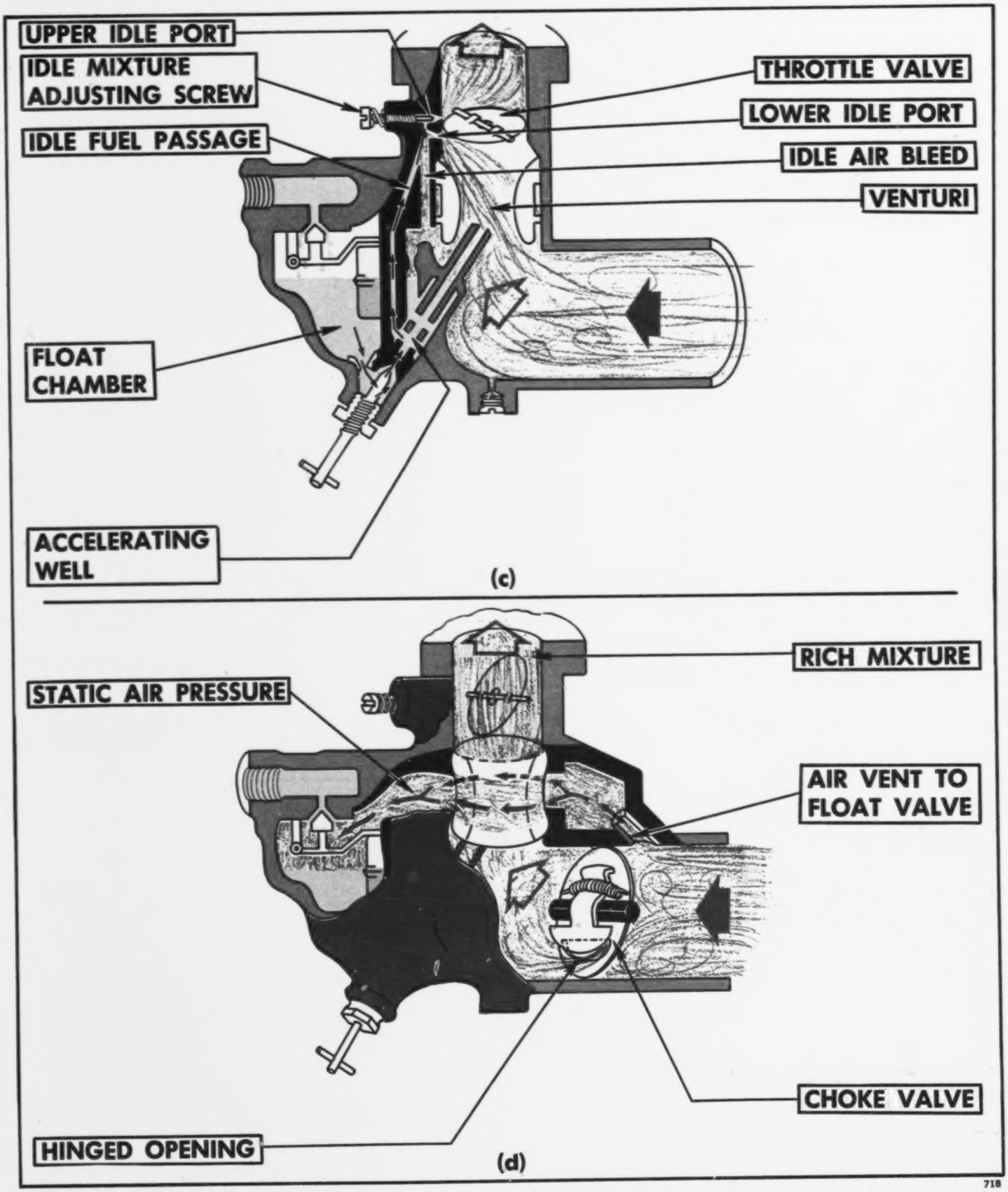

FUEL AIR MIXTURE
TO ENGINE
THROTTLE VALVE
FUEL INLET
VENTURI
NOZZLE
FLOAT VALVE
FLOAT CHAMBER
FUEL FLOAT
AIR INLET
HIGH-SPEED LOAD ADJUSTING NEEDLE
OVERFLOW DRAIN WITH SCREEN OR FELT COVER
(a)
LOW-PRESSURE AREA
AIR BLEED
NOZZLE ASSEMBLY
AIR INLET
ACCELERATING WELL
(b)
718

FIGURE 104. Float-type carburetor. (a) Basic features needed to supply a fuel-air mixture for an engine operating at constant load and constant speed. (b) Accelerating well and air bleed added to provide proper mixture for sudden load demands and heavy loads that continue for


UPPER IDLE PORT
IDLE MIXTURE ADJUSTING SCREW
IDLE FUEL PASSAGE
THROTTLE VALVE
LOWER IDLE PORT
IDLE AIR BLEED
VENTURI
FLOAT CHAMBER
ACCELERATING WELL
RICH MIXTURE
STATIC AIR PRESSURE
AIR VENT TO FLOAT VALVE
CHOKE VALVE
HINGED OPENING
718

(c)

(d)

short periods. (c) Added provisions supplying proper fuel-air mixture for idling. (d) Addition of choke valve for starting and provision for keeping air pressure the same in the float chamber and in the carburetor inlet.

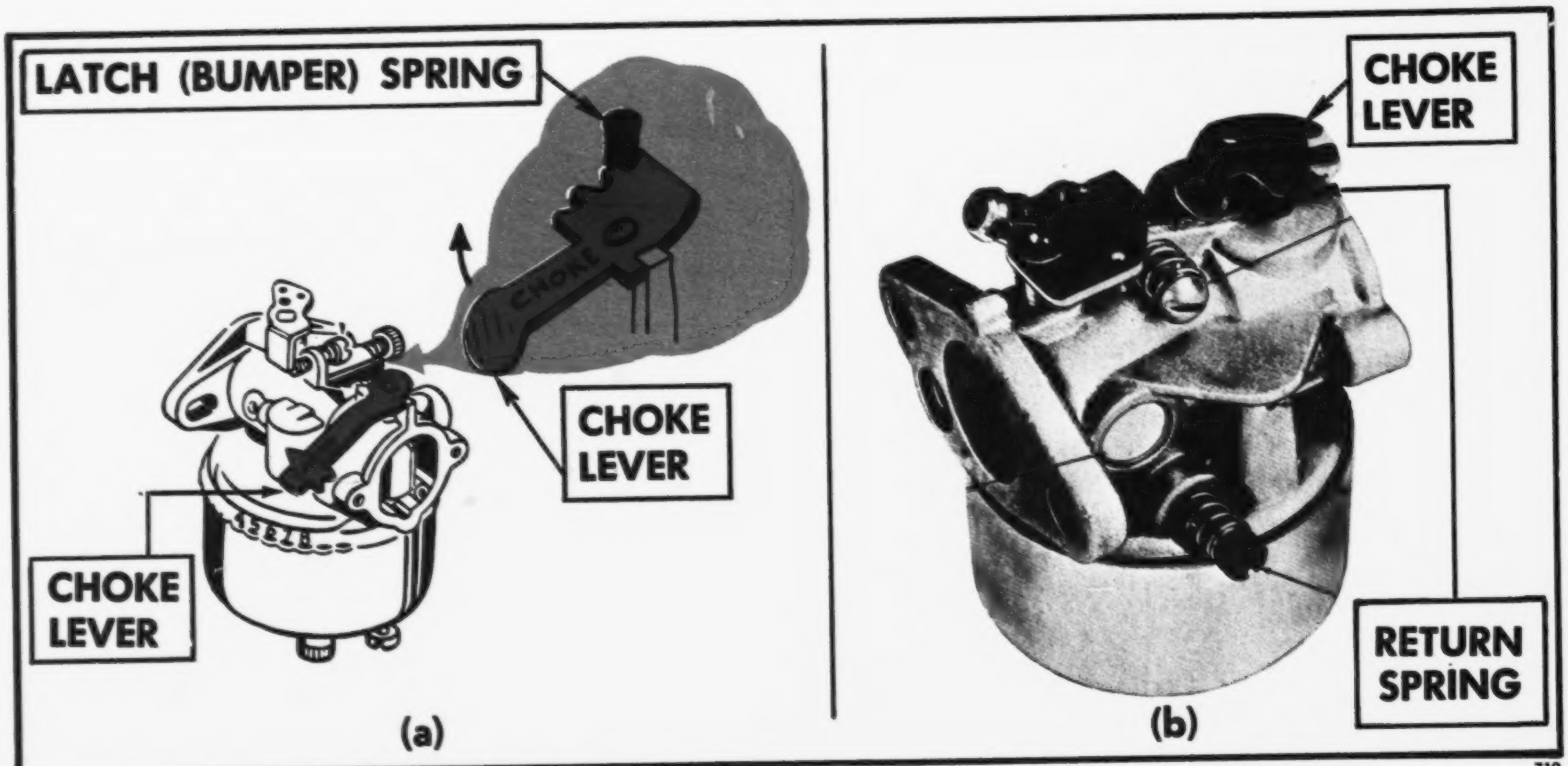

LATCH (BUMPER) SPRING
CHOKE
CHOKE LEVER
CHOKE LEVER
(a)
CHOKE LEVER
RETURN SPRING
(b)
719

FIGURE 105. Choke control valves may (a) latch in several different positions, or (b) they may be spring loaded to open all the way as soon as released.

would have to be exposed to atmospheric pressure. Atmospheric pressure would be enough more than that of the air in the carburetor duct to force extra fuel through the nozzle tip and make the mixture too rich.

There are, however, some float-type carburetors which are vented to the atmosphere through a small drilled hole in the carburetor housing. Sometimes this hole becomes clogged with dirt or gum and causes a low pressure area in the float chamber, thus limiting the fuel flow.

The **choke valve** is located at the carburetor air intake (Figures 101 and 104). It is the one you close when starting a cold engine in order to

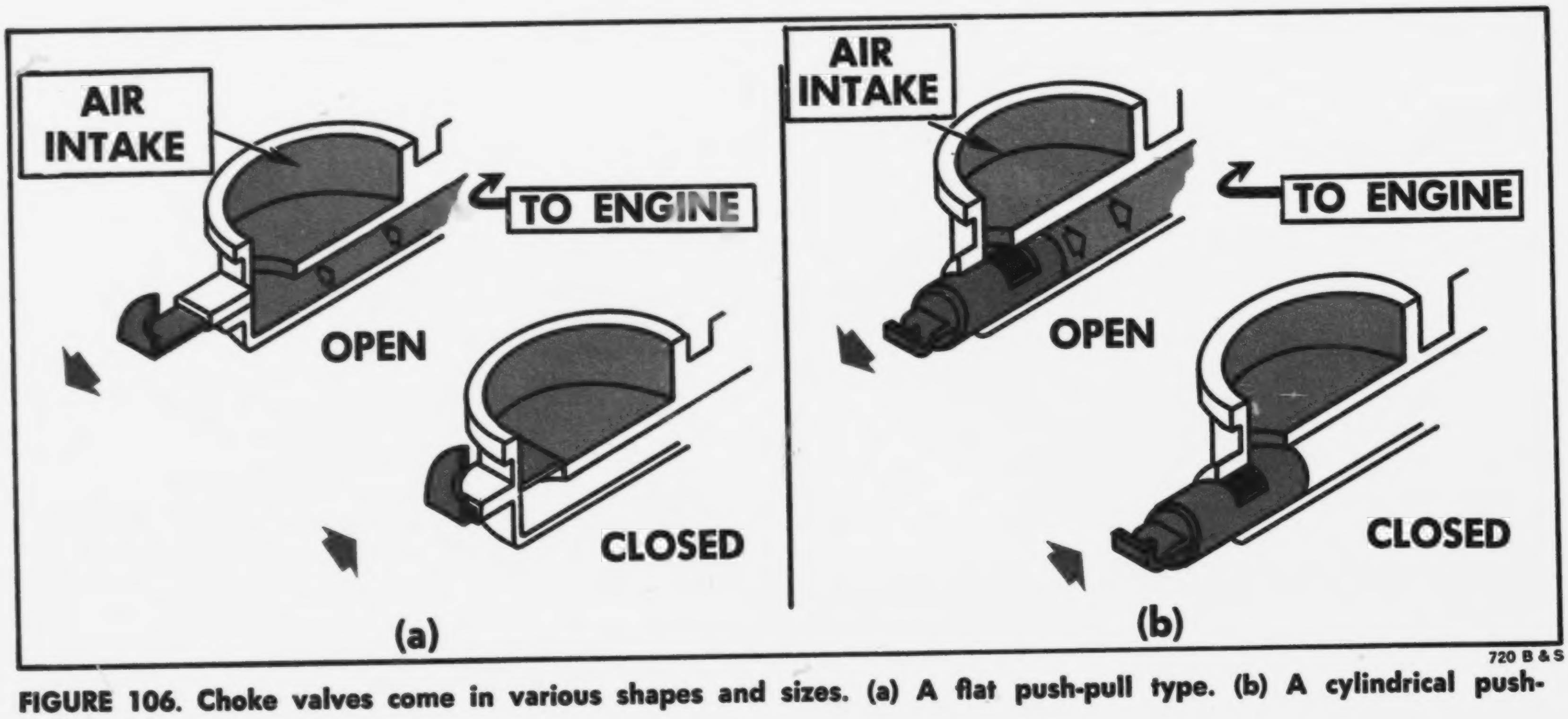

AIR INTAKE
TO ENGINE
OPEN
CLOSED
(a)
AIR INTAKE
TO ENGINE
OPEN
CLOSED
(b)
720 B & S

FIGURE 106. Choke valves come in various shapes and sizes. (a) A flat push-pull type. (b) A cylindrical push-pull type.

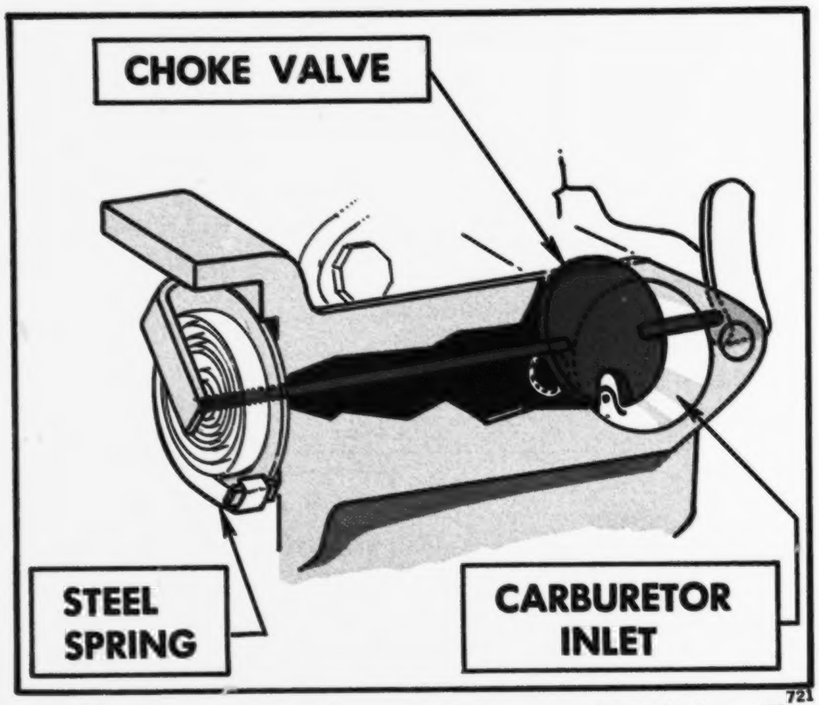


FIGURE 107. Principles of an automatic choke. The outer end of a steel spring is anchored to the engine near the exhaust manifold. The inside end is anchored to the choke valve. As the spring expands in length and contracts because of temperature changes, the choke valve turns. It is adjusted to open when the engine gets warm and to close when the engine cools.

provide an extra-rich starting mixture. Some are opened and closed automatically. When you choke your engine, you close the choke valve so that the air supply is almost cut off. What air is supplied passes either the edges of the choke valve or through a special opening provided through the choke valve. With most of the air supply cut off, a greater vacuum develops in the manifold, thus causing an increasing amount of fuel to be supplied through the fuel nozzle.

Some *manually operated choke valves* are designed to latch in fully open position, and some are designed to latch in the fully-closed position. Others have intermediate latch positions (Figure 105a). Some are spring loaded to open, and you have to hold them closed for starting (Figure 105b).

Not all choke valves are of the butterfly type. They come in various shapes (Figure 106).

Automatic chokes have variable positions depending on the temperature of the engine. Most automatic chokes take advantage of the principle that metal expands when heated and contracts when cooled (Figure 107). The coil spring lengthens when heated and shortens when cooled, thereby giving the rotating motion needed to open and close the choke valve.

Some are combination electric-thermostats. They are used on remote controlled engines, such as engine-driven electric generators. These are not commonly used.

Some engines have no choke valve, but have a **primer** instead (Figure 108). A primer is a type of pump with which you can actually pump extra gasoline into the carburetor air intake. They are used on most all multi-position engines and some vertical and horizontal position engines.

Examples of commercial *float-type carburetors*, used on small engines, are shown in Figure 109.

SUCTION-LIFT CARBURETOR

The **suction-lift carburetor** is a second type. It is usually mounted on top of the fuel tank (Figures 110 and 111). It is used primarily on inexpensive 4-cycle engines.

Vacuum from the engine intake stroke—downward motion of the piston, 4-cycle engine (Figure

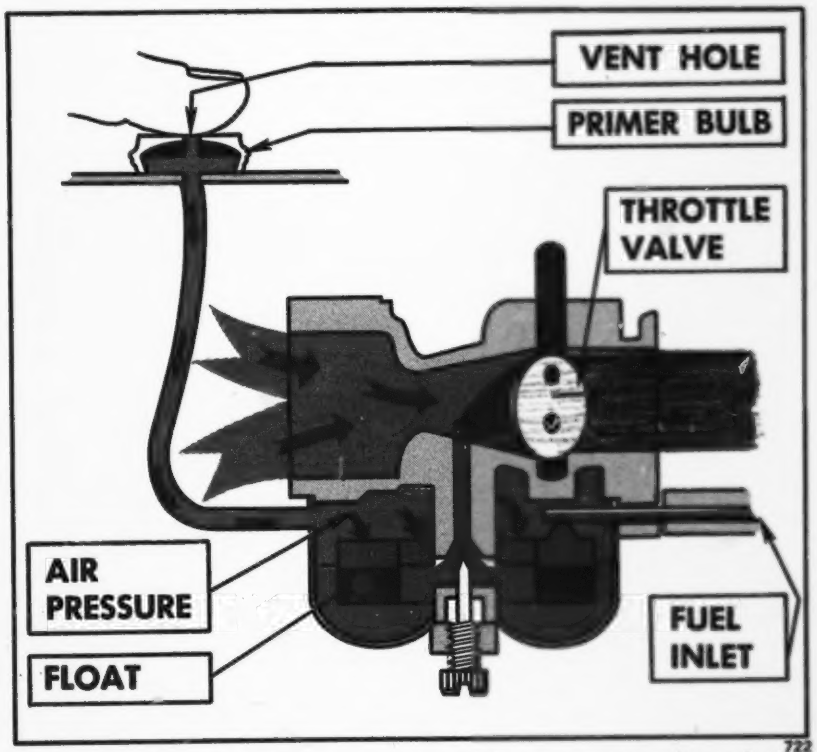


FIGURE 108. A bulb-type primer. To operate, close bulb vent hole with finger; then depress bulb. Fuel is forced from the carburetor float chamber into the venturi for a richer starting mixture.

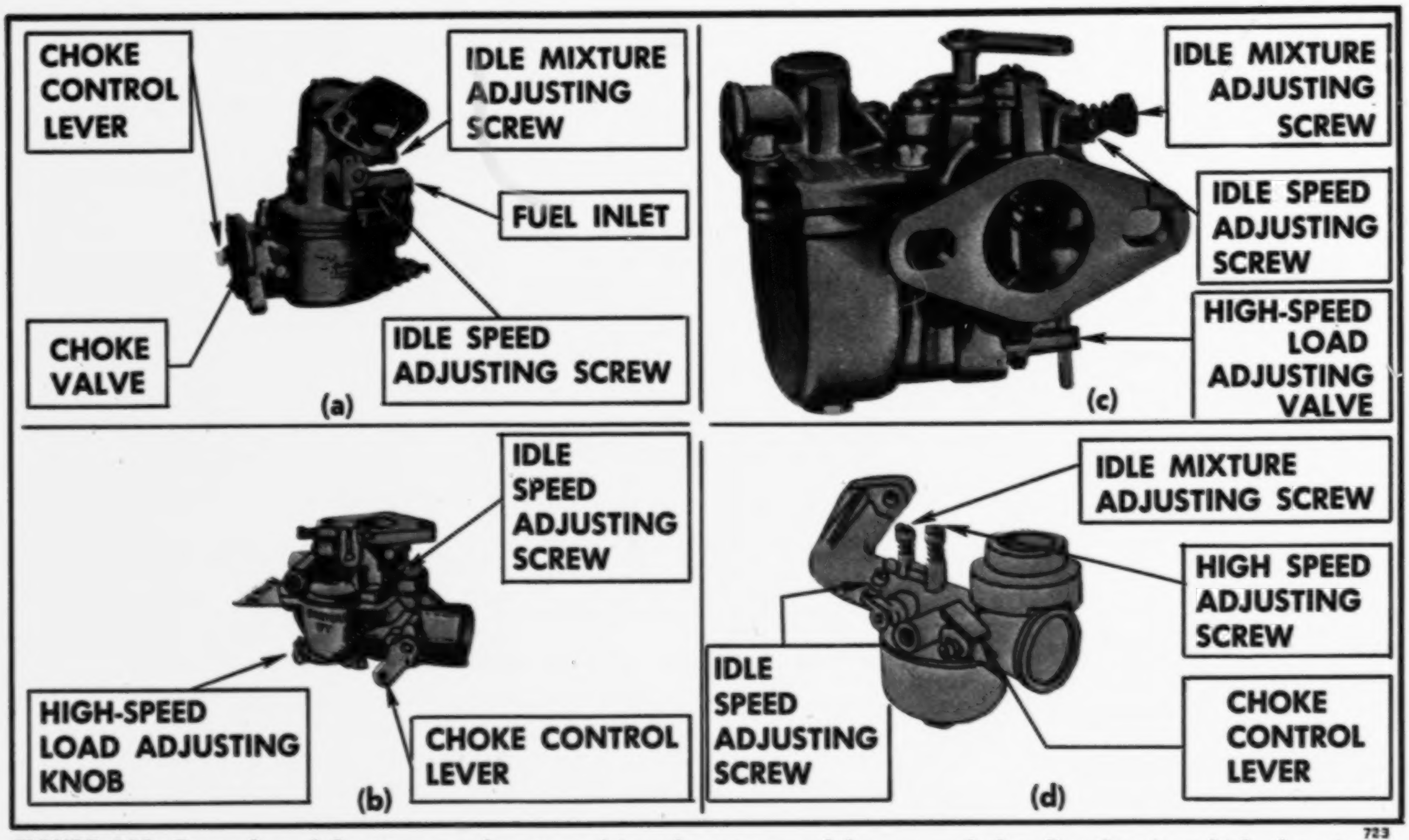

CHOKE CONTROL LEVER
IDLE MIXTURE ADJUSTING SCREW
FUEL INLET
CHOKE VALVE
IDLE SPEED ADJUSTING SCREW
(a)
IDLE MIXTURE ADJUSTING SCREW
IDLE SPEED ADJUSTING SCREW
HIGH-SPEED LOAD ADJUSTING VALVE
(c)
IDLE SPEED ADJUSTING SCREW
HIGH-SPEED LOAD ADJUSTING KNOB
CHOKE CONTROL LEVER
(b)
IDLE MIXTURE ADJUSTING SCREW
HIGH SPEED ADJUSTING SCREW
IDLE SPEED ADJUSTING SCREW
CHOKE CONTROL LEVER
(d)
723

FIGURE 109. Examples of float-type carburetors. (a) and (b) Updraft types. (c) and (d) Side-draft types. They are so named because of the direction in which the air is drawn through the carburetor.

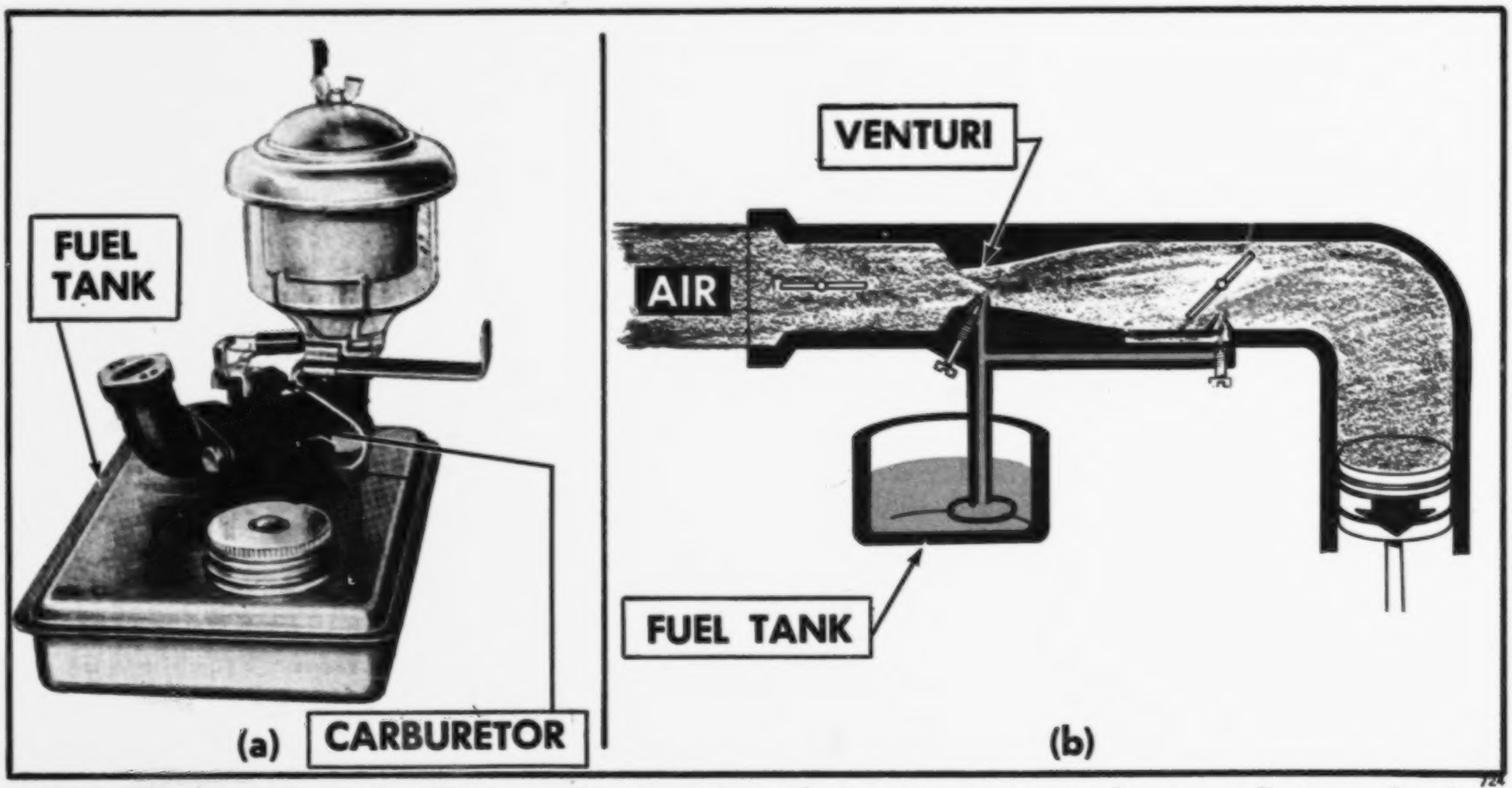

FUEL TANK
(a)
CARBURETOR
VENTURI
AIR
FUEL TANK
(b)
724

FIGURE 110. A simple suction-lift type carburetor. (a) Exterior view. (b) This suction-lift type carburetor has no carburetor fuel reservoir but depends upon the fuel tank. It may or may not have an adjustment for the idling valve.

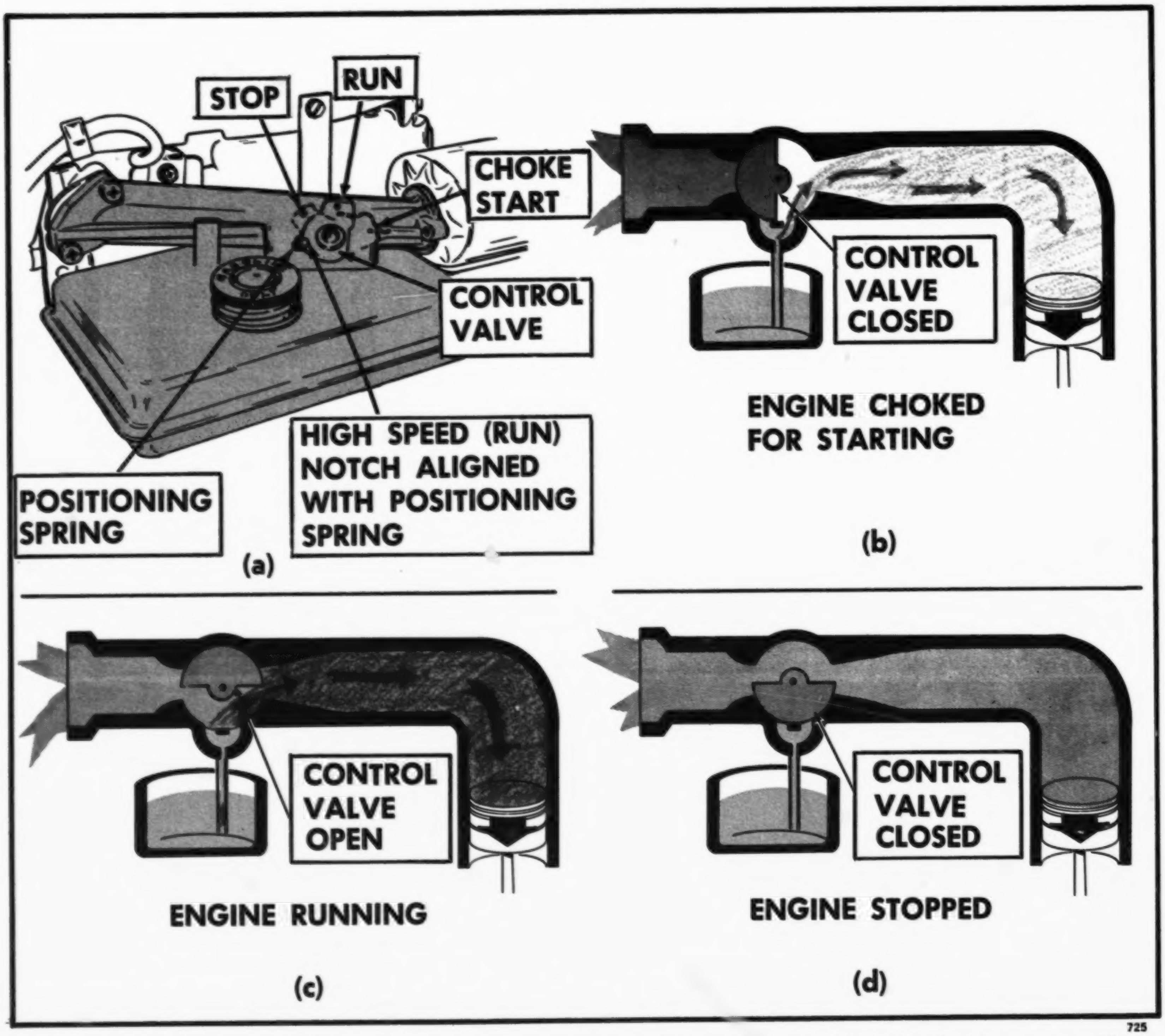

STOP
RUN
CHOKE START
CONTROL VALVE
HIGH SPEED (RUN) NOTCH ALIGNED WITH POSITIONING SPRING
POSITIONING SPRING
(a)
CONTROL VALVE CLOSED
ENGINE CHOKED FOR STARTING
(b)
CONTROL VALVE OPEN
ENGINE RUNNING
(c)
CONTROL VALVE CLOSED
ENGINE STOPPED
(d)
725

FIGURE 111. A suction-type carburetor designed to start, run and stop from only one control. (a) Three positions of the control valve. (b) Cross section of control valve in choke position. (c) Control valve in run position. (d) Control valve in stop position.

110b), or upward motion of the piston, 2-cycle engine—causes low pressure in the venturi. Atmospheric pressure forces fuel up through the tube into the low pressure area of the venturi and then into the engine.

The horsepower is limited on engines using this type of simple carburetor. This is because the suction lift is quite limited. Fuel flow to the carburetor varies with the amount of fuel in the tank. For engines of ½ to 3 horsepower, however, it works satisfactorily.

One suction-lift type carburetor is designed with a means for choking, running and stopping—all in one control valve (Figure 111).

Larger sizes of suction-lift carburetors include a *diaphragm fuel pump* which fills an auxiliary fuel reservoir (Figure 112). (Do not confuse this diaphragm pump with the diaphragm type carburetor

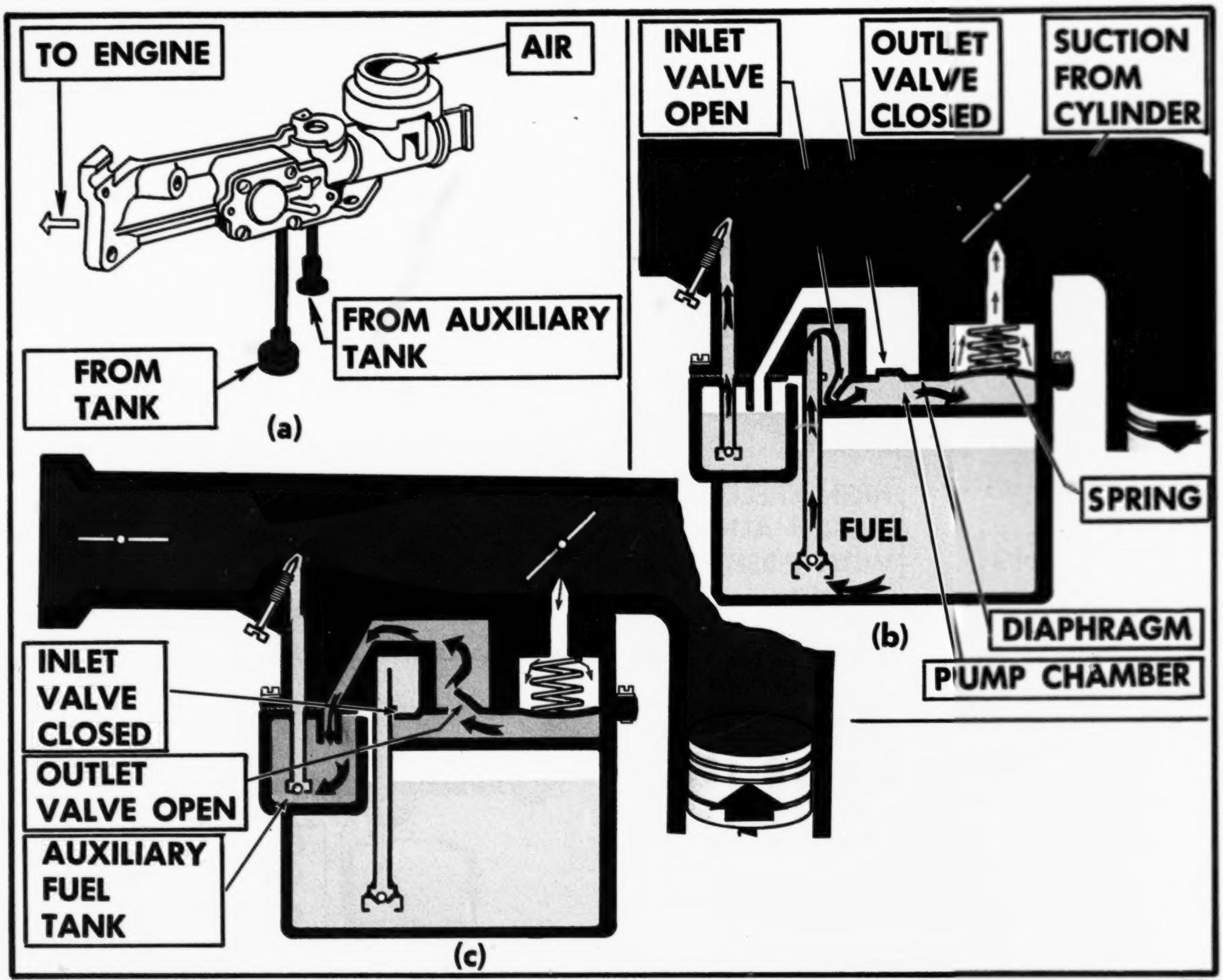

TO ENGINE
AIR
FROM AUXILIARY TANK
FROM TANK
(a)
INLET VALVE OPEN
OUTLET VALVE CLOSED
SUCTION FROM CYLINDER
FUEL
SPRING
(b)
DIAPHRAGM
PUMP CHAMBER
INLET VALVE CLOSED
OUTLET VALVE OPEN
AUXILIARY FUEL TANK
(c)
726

FIGURE 112. A suction-lift type carburetor and fuel pump combination. (a) Outside view. (b) Schematic view of pump intake. (c) Schematic view showing pump discharge into the auxiliary fuel reservoir.

discussed on page 99.) With this design very little fuel "lift" is required to draw gasoline into the venturi. Since less suction is required, the venturi can be made larger, thus permitting a greater volume of fuel-air mixture to flow into the engine with a consequent increase in horsepower. Also, the fuel flow to the carburetor does not vary with different fuel levels in the tank.

Here is how the diaphragm pump works.

- *Fuel is drawn from the tank into the pump chamber (Figure 112b).*

The spring side of the diaphragm is connected to the intake manifold. Suction from the engine pulls the diaphragm toward the spring and compresses it. This movement creates low pressure on the opposite side of the diaphragm, which is the fuel side of the pump chamber. Fuel from the fuel tank is forced into the chamber by atmospheric pressure. The pressure of the fuel opens the inlet flapper valve and closes the outlet flapper valve. Fuel enters the pump chamber.

- *Fuel is then forced into the carburetor (auxiliary) reservoir (Figure 112c)*

At the end of the intake stroke the vacuum

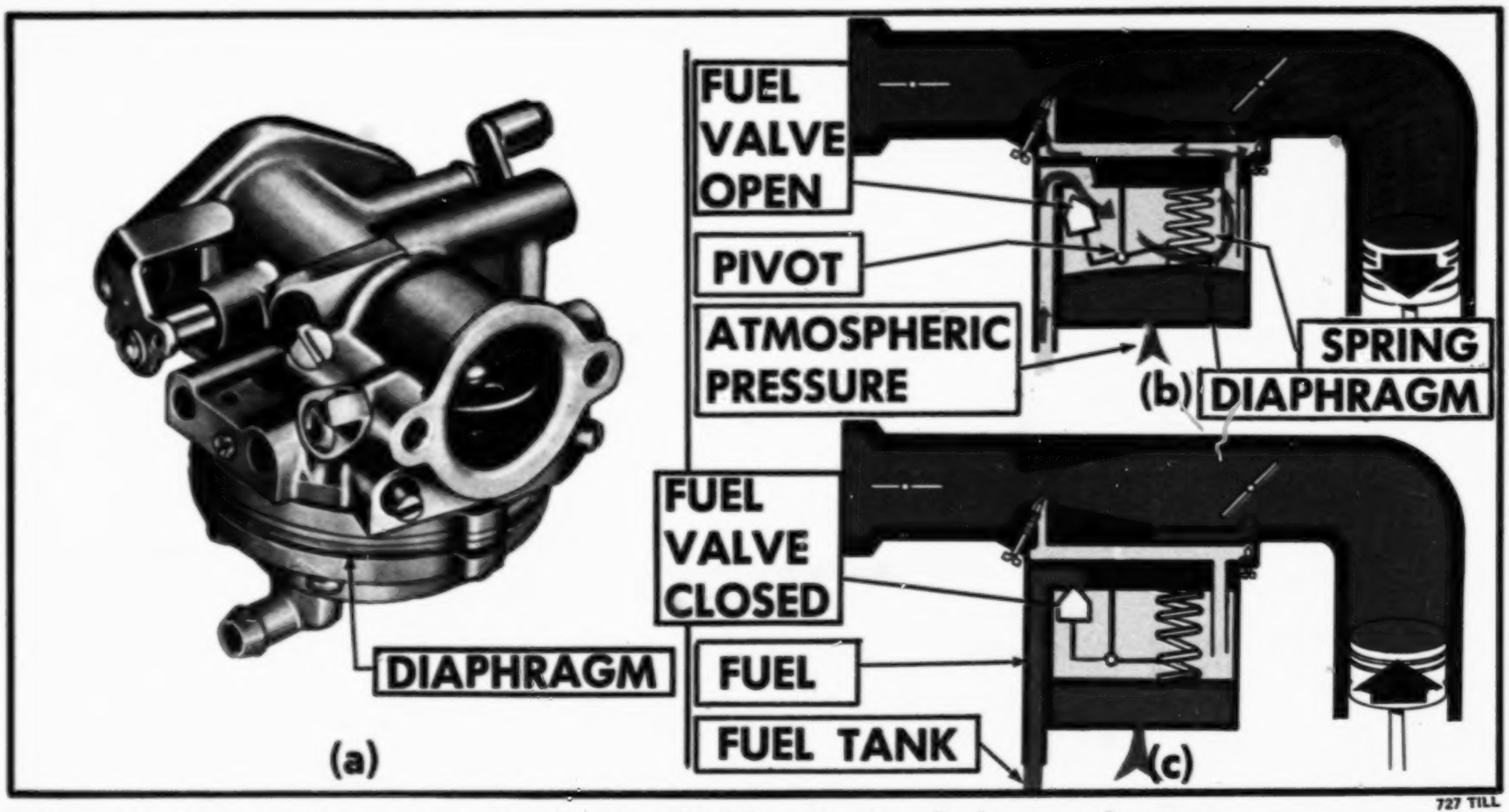


FIGURE 113. (a) A diaphragm type of carburetor. (b) Schematic of a diaphragm carburetor.

is relieved from behind the diaphragm. Spring tension returns the diaphragm to its original position and forces the fuel into the auxiliary reservoir.

- *Fuel is forced into the (venturi) carburetor throat from the reservoir in the same manner as that from the suction-lift carburetor shown in Figure 110.*

DIAPHRAGM-TYPE CARBURETOR

The **diaphragm-type carburetor** is a third kind. It uses a spring-loaded diaphragm for regulating the fuel flow into the carburetor fuel chamber. The diaphragm serves the same purpose as the float in the float type carburetor, but the use of the diaphragm allows engines to be operated at any angle (Figure 113). This feature makes this type of carburetor adaptable to multi-position engines, but they are also used on vertical and horizontal position engines. Do not confuse this with the diaphragm pump just described. Many diaphragm carburetors, however, also use a diaphragm pump in addition to the valve-activating diaphragm.

It is especially adaptable to *2-cycle engines* which provide for activating the diaphragm from low pressure in the crankcase.

Here is how it works. As the piston moves (down, 4-cycle engine, or up, 2-cycle engine), suction is created in the venturi section of the carburetor. Atmospheric pressure forces the diaphragm up. The fuel valve opens. Fuel enters the diaphragm chamber and flows on through into the venturi section and to the engine cylinder. When the piston moves in the opposite direction and no suction is created, the diaphragm valve closes and the diaphragm chamber and the fuel passageways remain full of fuel — ready for the next intake stroke. All this happens very rapidly and a constant supply of fuel is available to the engine.

TOOLS AND MATERIALS NEEDED

1. Slot-head screwdriver — 6″

   Phillips-head screwdriver — 6″

2. Open-end wrenches — 1/4″ through 1/2″
3. Needle-nose pliers

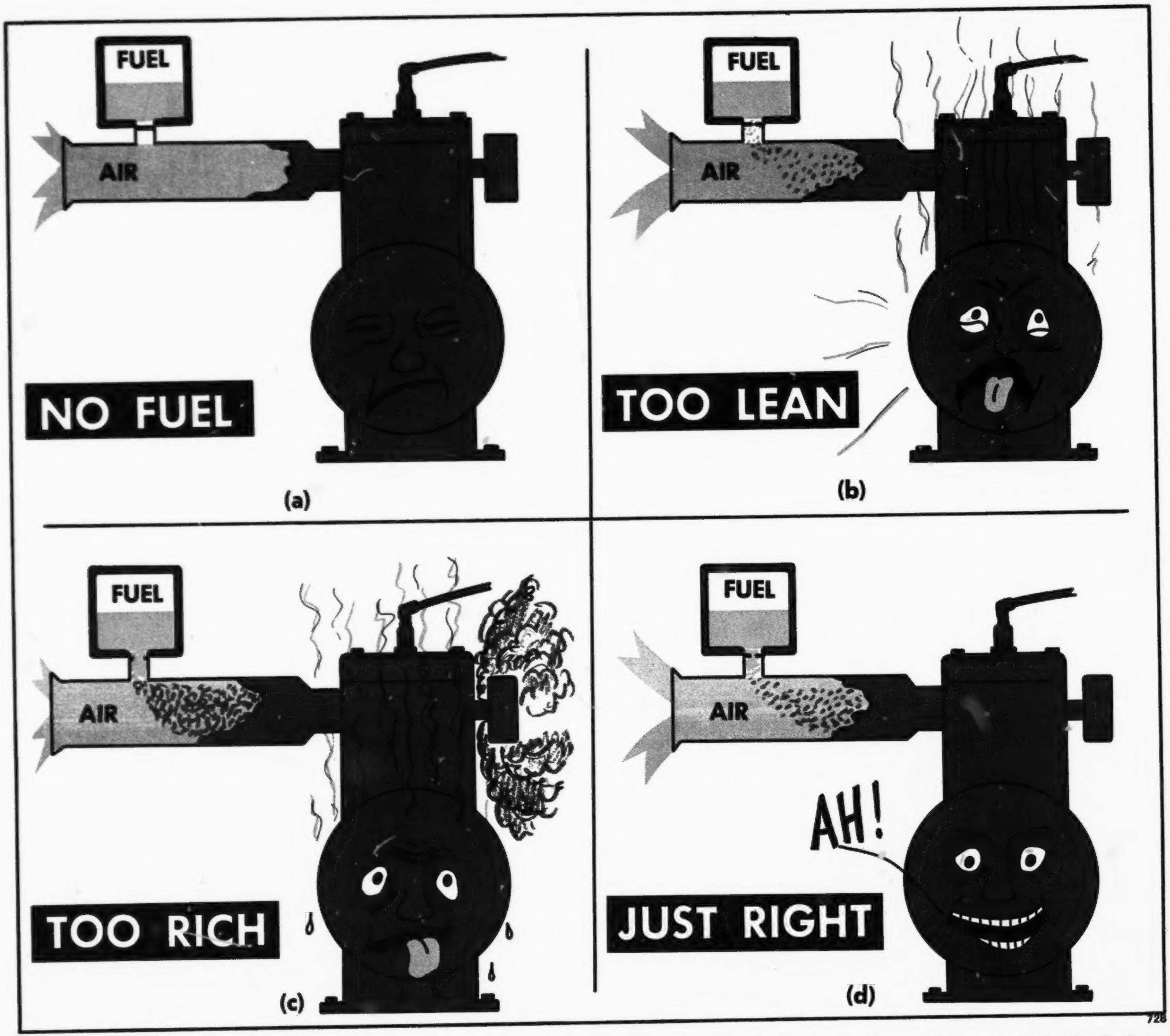

FUEL
AIR
NO FUEL
(a)
FUEL
AIR
TOO LEAN
(b)
FUEL
AIR
TOO RICH
(c)
FUEL
AIR
AH!
JUST RIGHT
(d)
728

FIGURE 114. Your carburetor may supply (a) no fuel flow, (b) too little fuel flow, (c) too much fuel flow (d) or the fuel flow may be just right.

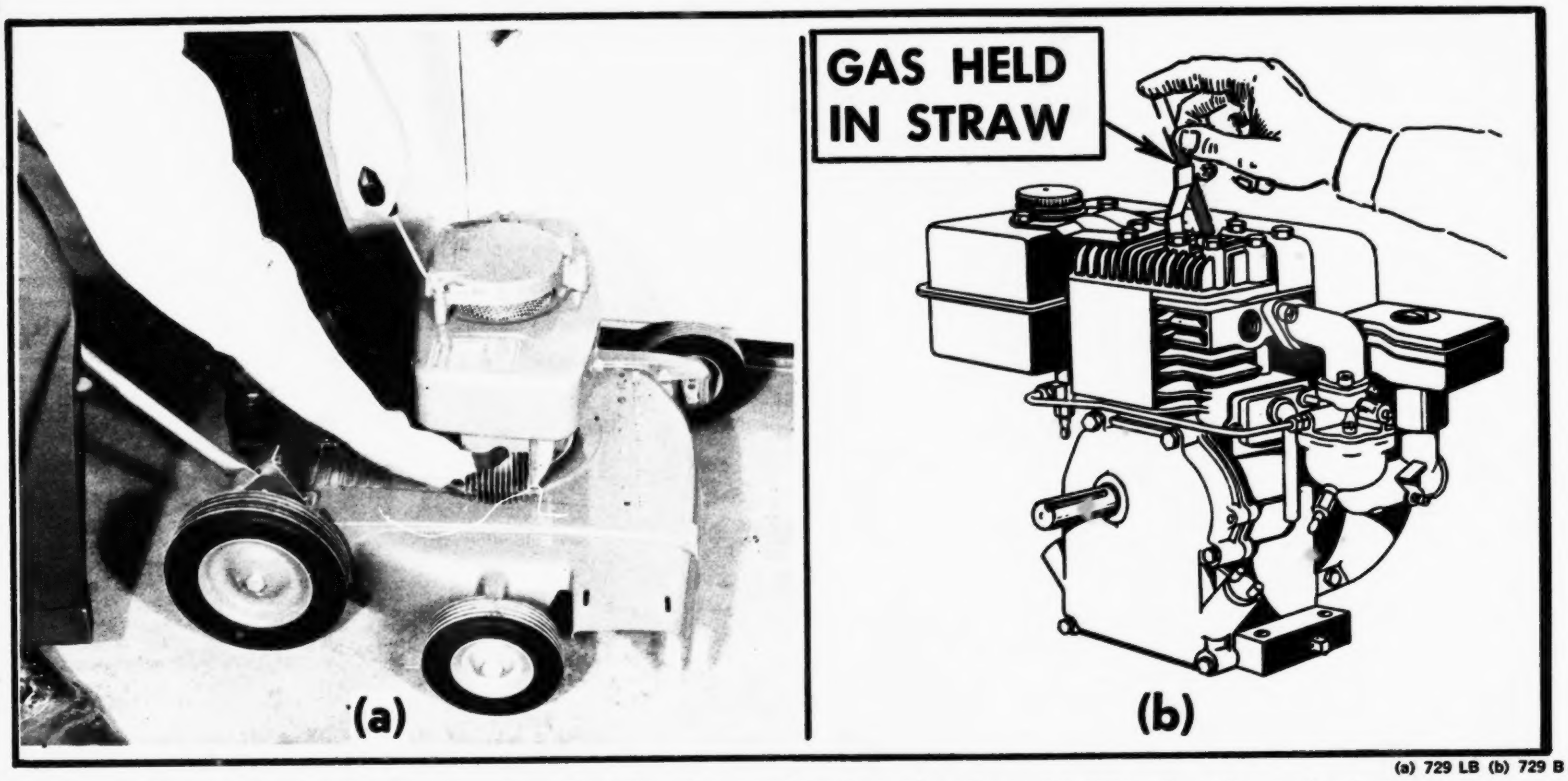
CHECKING THE CARBURETOR FOR PROPER OPERATION

Basically there are three conditions that indicate carburetor trouble:

- No fuel being supplied to the combustion chamber from the carburetor.
- Too little fuel being supplied to the combustion chamber from the carburetor.
- Too much fuel being supplied to the combustion chamber from the carburetor.

In order to determine if the carburetor is functioning properly, use the following procedures:

1. *Start the engine.*



(a) 729 LB (b) 729 B&S

FIGURE 115. Methods for testing for fuel in the combustion chamber. (a) Wet thumb method. (b) Adding fuel directly.

Follow procedures under "Starting Engines," page 124.

If the engine **does not start** and you have a strong spark at the spark plug, check to see how much, if any, fuel is being supplied to the combustion chamber by the carburetor.

Proceed as follows:

(1) *Remove the spark plug.*

(2) *Place your finger or thumb over the spark-plug hole (Figure 115a).*

(3) *Close the choke valve.*

(4) *Crank the engine with the starter 3 or 4 times (Figure 115a).*

(5) *Remove your finger.*

Your finger should be wet if fuel is being delivered to the cylinder by the carburetor.

If your **finger is wet,** the starting trouble is not in the carburetor — unless it is flooding.

If your **finger is not wet,** no fuel is getting to the engine. Make further carburetor checks. Proceed to step (6).

(6) *Put one-half teaspoon of gasoline into the combustion chamber (Figure 115b).*

You can do this by inserting a soda straw or length of small tubing into gasoline. When it fills, hold your finger over the top to hold the gasoline until you can insert the straw or tubing into the combustion chamber through the spark-plug hole. Then release. Do not put too much fuel into the combustion chamber or you will flood the engine and upset the test.

(7) *Reinstall spark plug.*

(8) *Start the engine.*

If engine starts and runs for a short time and then stops, this indicates that insufficient fuel is getting past the carburetor, and the trouble is most likely in the carburetor. See instructions for adjusting and repairing the carburetor.

If your engine does not start, this is an indication that the trouble is not in the carburetor unless it is flooding.

Allow the spark plug to dry and try starting again. If it still does not start, check and adjust the carburetor. Refer to "Repairing Carburetors," Volume II.

2. *Operate the engine at idling speed for warm-up.*

3. *Advance the throttle suddenly.*

   The engine should accelerate smoothly and evenly. If it does not, this indicates the fuel mixture is too lean. Also, a high operating temperature indicates a lean mixture.

   Adjust the carburetor.

4. *Check the exhaust smoke.*

   If the engine gives off black smoke, burns an excessive amount of fuel and idles rough, the fuel mixture is too rich. Adjust the carburetor.

   Two-cycle engines should smoke slightly because of the oil in the fuel.

PREPARING FOR CARBURETOR ADJUSTMENT

Before you can adjust your carburetor properly, there are several jobs you should do.

The following procedures apply to all three types of carburetors.

1. *Fill the fuel tank with clean, fresh gasoline.*

   Most small engine manufacturers prefer **regular grade gasoline.**

   There is one exception to filling the fuel tank before adjusting the carburetor.

   If you have a **simple suction-lift type carburetor that has no reservoir** (Figure 110), fill the tank half full. This is because the fuel mixture varies with the amount of fuel in the tank. Adjusting the carburetor at the half-full level will give you an average fuel-air mixture for which the carburetor was designed.

2. *Check the throttle and governor linkage for mechanical condition and freedom of action.*

3. *Service the engine.*

   The following service jobs should be performed before attempting to adjust the carburetor; otherwise, the adjustment will not be accurate.

   Check the crankcase oil level. Refer to "Lubricating Small Engines," page 57.

   Check the fuel-tank vent. It is in the fuel-tank cap. Make sure it is not restricted. If it is restricted, fuel will not flow to the carburetor. Your engine may start but it will not run very long.

   Service the fuel strainer(s). Refer to "Servicing Fuel Strainers," page 44.

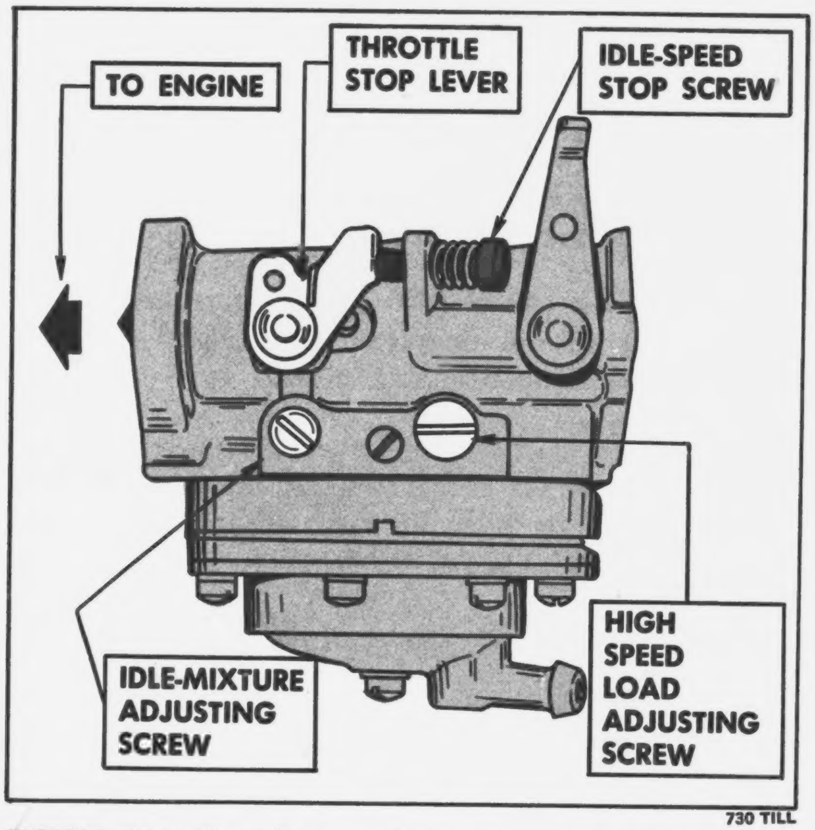
   Service the air cleaner. A partially clogged air cleaner will tend to choke the engine and cause a richer than normal mixture.

   Refer to "Servicing Carburetor Air Cleaners," page 32.

4. *Check for air leaks in the carburetor manifold.*

   This also includes checking for air leaks in the crankcase of **2-cycle engines.** If you suspect a leak at any point, put a drop of oil on the suspected area, crank the engine, and see if the oil disappears. If so, you have an air leak.

   If you have an **air leak,** tighten the flanges and recheck. It may be necessary to replace the gasket(s).


TO ENGINE
THROTTLE STOP LEVER
IDLE-SPEED STOP SCREW
IDLE-MIXTURE ADJUSTING SCREW
HIGH SPEED LOAD ADJUSTING SCREW

730 TILL

FIGURE 116. The idle speed stop screw is easy to find.

5. *Check the ignition.*

   Poor ignition will give you a false carburetion check.

   Refer to "Checking the Spark Plug for Proper Operation," page 78.

6. *Locate the idle-speed stop screw (Figure 116).*

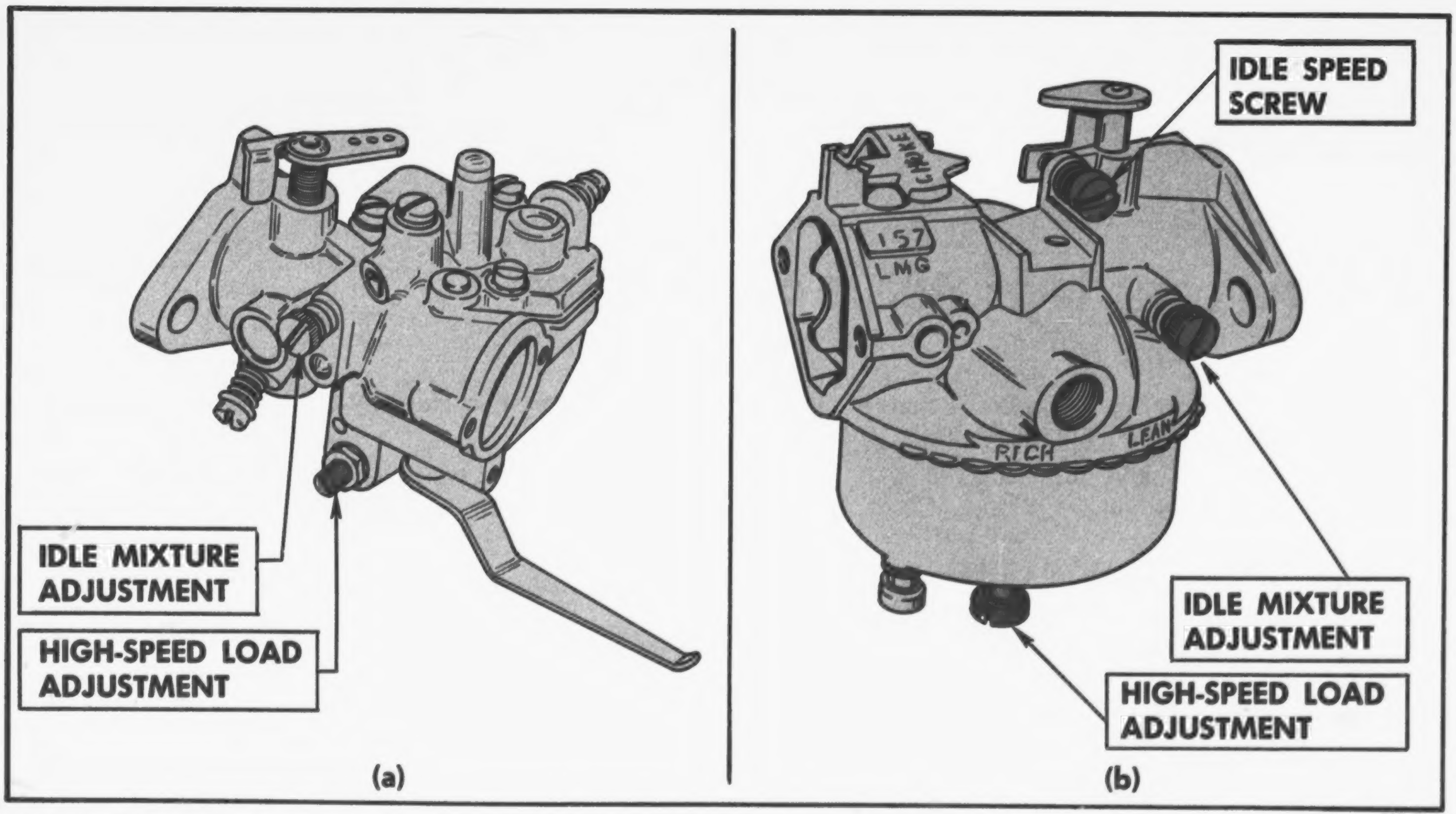
   If you cannot find the stop screw, operate the throttle control and notice where the linkage is attached to the carburetor. The stop screw limits the travel of the throttle valve toward the closed position.

7. *Locate and identify the fuel-air mixture adjusting screws (Figure 117).*

   There are two of them on most carburetors — an **idle-mixture adjustment** and a **high-speed load-adjustment** screw.

   On most carburetors the **idle-mixture adjustment** is the screw nearer the engine. This, however, is not always true.

   If **you are not sure,** start the engine and operate it at idle speed. Turn the most likely adjusting screw to closed position (clockwise in most cases).


IDLE MIXTURE ADJUSTMENT
HIGH-SPEED LOAD ADJUSTMENT
IDLE SPEED SCREW
CHOKE
157
LMG
RICH
LEAN
IDLE MIXTURE ADJUSTMENT
HIGH-SPEED LOAD ADJUSTMENT

(a) (b)

730 TILL

FIGURE 117. Typical carburetors showing fuel-air mixture adjusting screws.

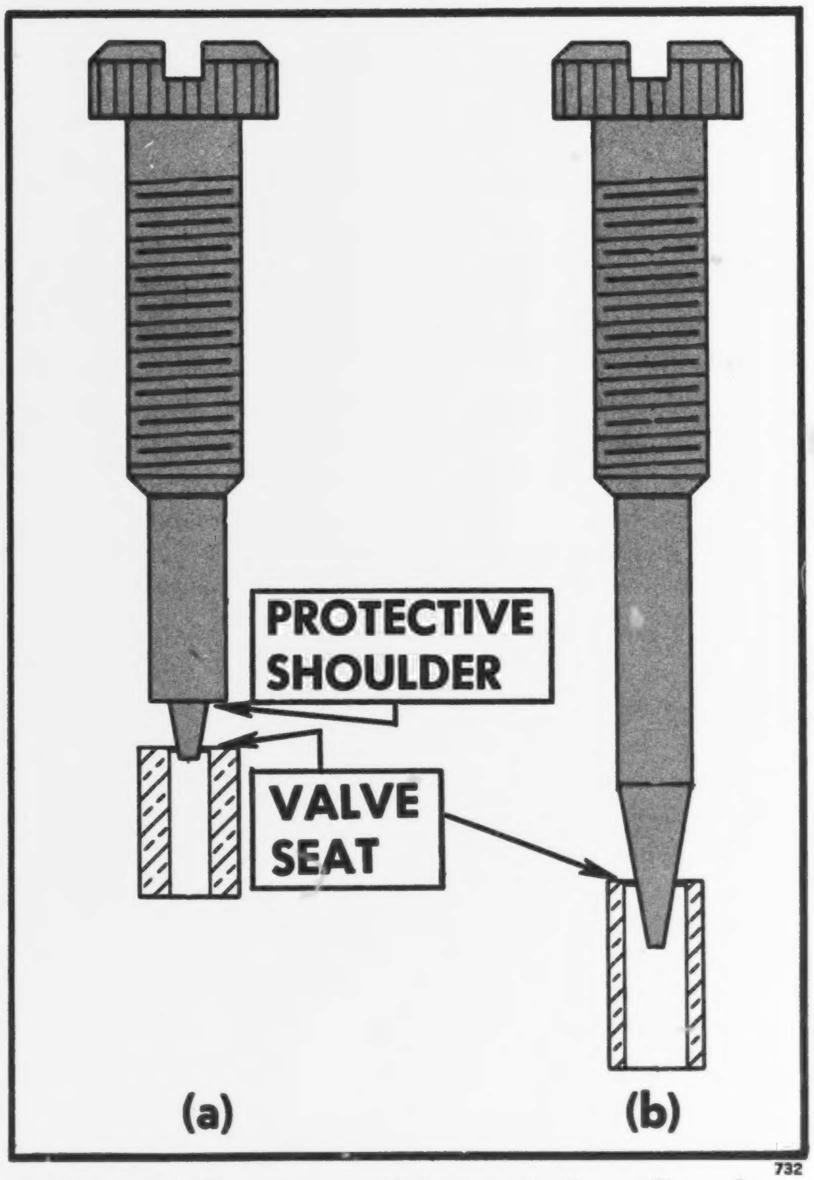


FIGURE 118. Two types of fuel control needle valves. (a) Needle valve with a protective shoulder. (b) Needle valve without a protective shoulder.

If the engine slows down or stops, you have closed the idle-mixture adjusting needle.

If there is no noticeable difference in the engine speed, try changing the engine speed to ½ to ¾ throttle.

If you get a difference in operation at this speed, then you have closed the high-speed load-adjusting needle.

A few carburetors have no idle-mixture adjustment. It is fixed by the size of the drilled discharge port in the carburetor (Figures 110 and 111).

8. *Make initial carburetor adjustments.*

   Turn each of the adjusting needles all the way in by hand (usually clockwise). Then open them by approximately one turn. This amount varies from ¾ to 1½ turns on different carburetors. Check your operator's manual.

   These are the best general recommendations the manufacturer can provide, but slight variations in adjustment are necessary on different engines for smoothest operation.

NOTE: Never tighten the adjusting screws more than finger tight. There is danger of damaging the needle and seat on the type shown in Figure 118b.

ADJUSTING THE CARBURETOR CHOKE VALVE

Adjustment of the choke valve is usually limited to the adjustment of the choke-valve linkage in manually-operated valves, and adjusting the spring tension on spring-operated automatic choke valves.

There are four types of chokes used on small engines: (1) **manual (separate valve),** (2) **automatic (heat sensitive spring),** (3) **automatic (thermostat and solenoid)** and (4) **manual (combination throttle and choke valve).**

a. If your carburetor has an **adjustable manual choke valve,** the adjustment will be in the control linkage (Figure 119). Adjust it as follows:

1. *Remove carburetor air cleaner.*

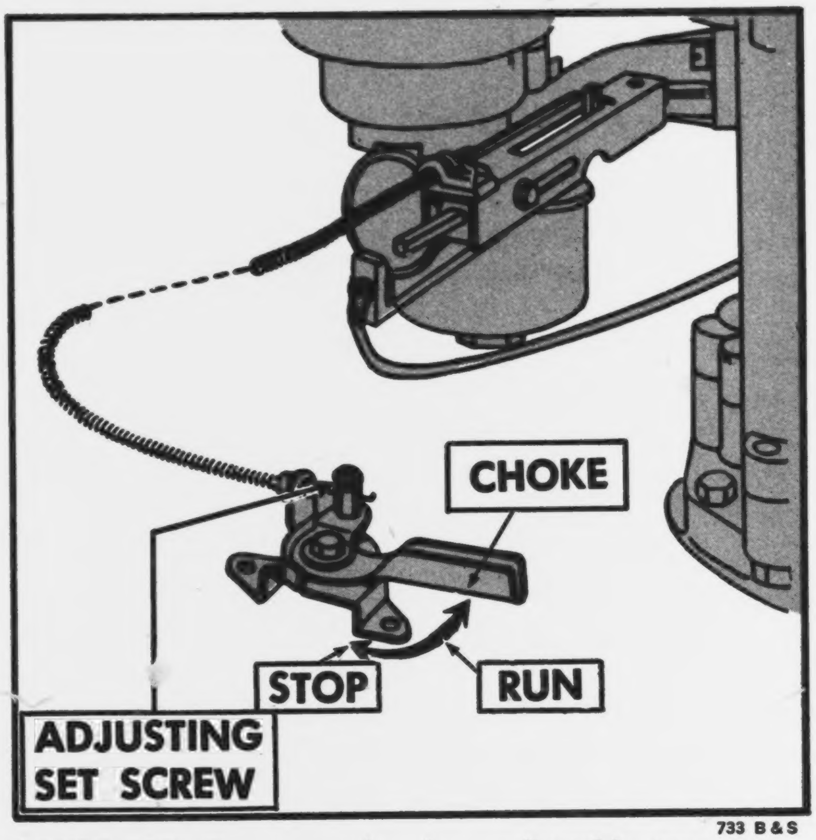
   This enables you to see the choke-valve position.

2. *Close choke valve with control.*

   Check for freedom of operation.

3. *Observe position of the valve after closing the control.*

   The valve should be completely closed.


CHOKE
STOP
RUN
ADJUSTING SET SCREW

733 B & S

FIGURE 119. One example of an adjustable type manually operated choke valve.

If it is not closed, adjust the control linkage.

Loosen the set screw (Figure 119), close the choke valve and then tighten the set screw.

4. *Open choke valve with the control.*

   It should open all the way.

   If it does not open, recheck your adjustment in step 3.

b. If your carburetor has an **automatic choke which is operated by the heat-sensitive (thermostat) spring, Figures 108 and 120),** adjust it as follows:

1. *Remove air cleaner.*

2. *Observe position of the choke valve.*

   Adjustment must be made while the engine is cold. Valve should be closed at room temperature. If you make adjustments while the engine is warm, the spring will be expanded and will have a tendency to open the valve.

   If valve is not closed, proceed to step 3.

3. *Loosen adjusting lock screw (Figure 120).*

   Some have lock screw on the spring bracket (Figure 120a), and some have a set screw on the adjusting arm (Figure 120b).

4. *Move adjusting link until choke is closed.*

5. *Tighten adjusting lock screw.*

c. If your automatic choke is **controlled by a combination electric-thermostat (Figure 121),** proceed as follows:

1. *Turn ignition switch off.*

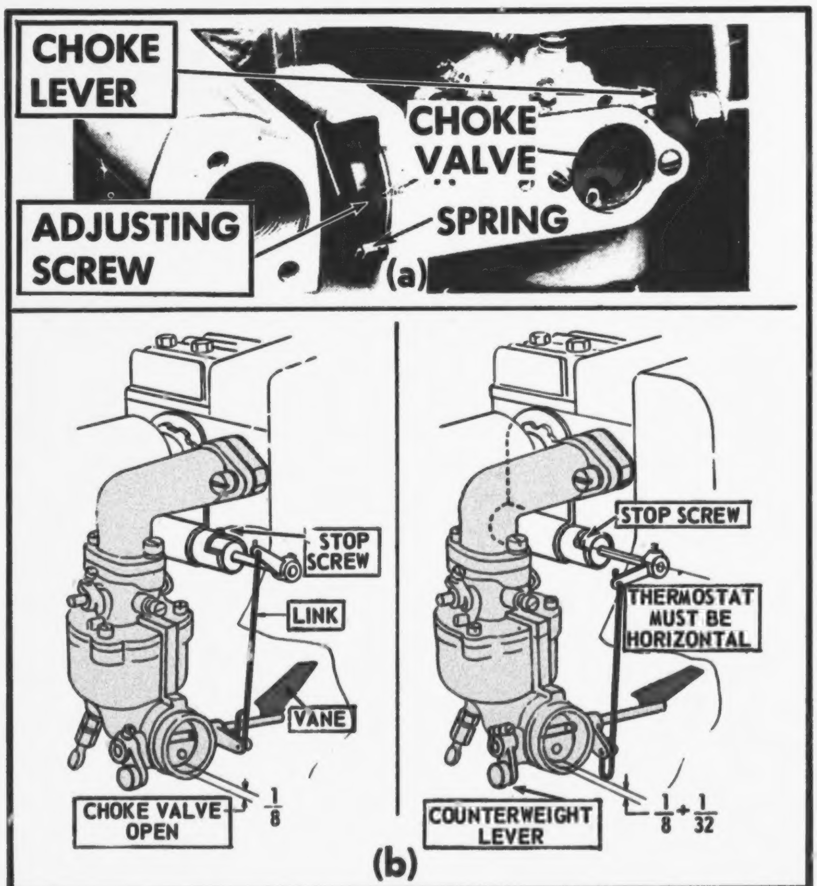
2. *Close fuel shut-off valve.*

3. *Remove carburetor air cleaner.*

4. *Operate starter and observe the extreme position of the solenoid lever arm and choke valve.*

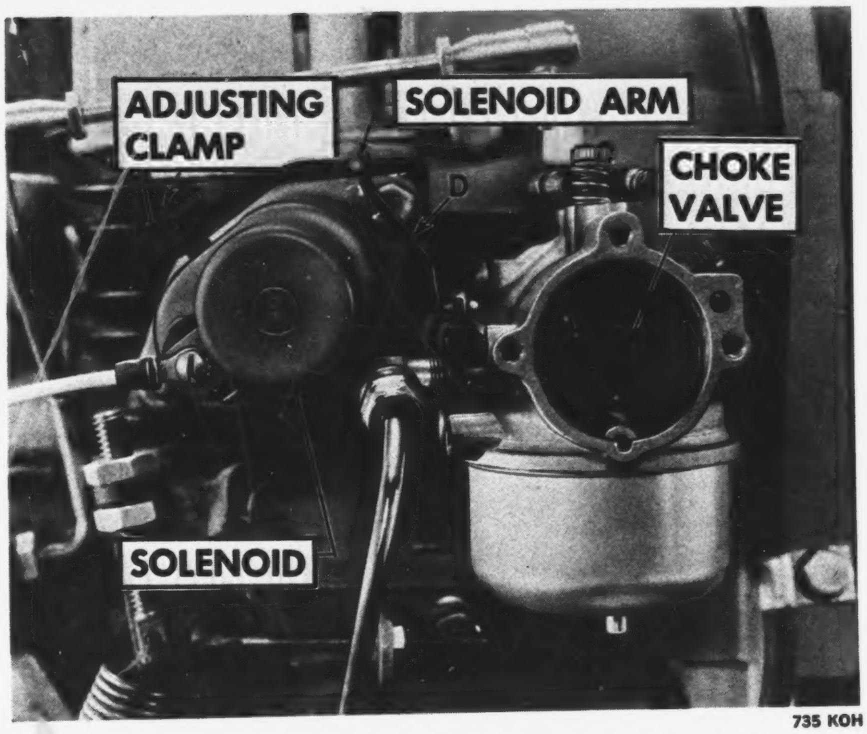
   This should be done with the engine cold.

   Choke valve should be closed.


CHOKE LEVER
CHOKE VALVE
ADJUSTING SCREW
SPRING
(a)
STOP SCREW
LINK
VANE
CHOKE VALVE OPEN
1/8
STOP SCREW
THERMOSTAT MUST BE HORIZONTAL
COUNTERWEIGHT LEVER
1/8 + 1/32
(b)

(a) 734 KOH (b) 734 B & S

FIGURE 120. (a) Automatic choke operated by an accessible heat-sensitive spring (thermostat) (b) Automatic choke-control linkage connecting thermostat to choke valve. Choke valve is opened by air pressure against a vane when the engine is operating.



735 KOH

FIGURE 121. A combination electric-thermostat controlled choke.

If the choke valve is not closed, proceed to step 5.

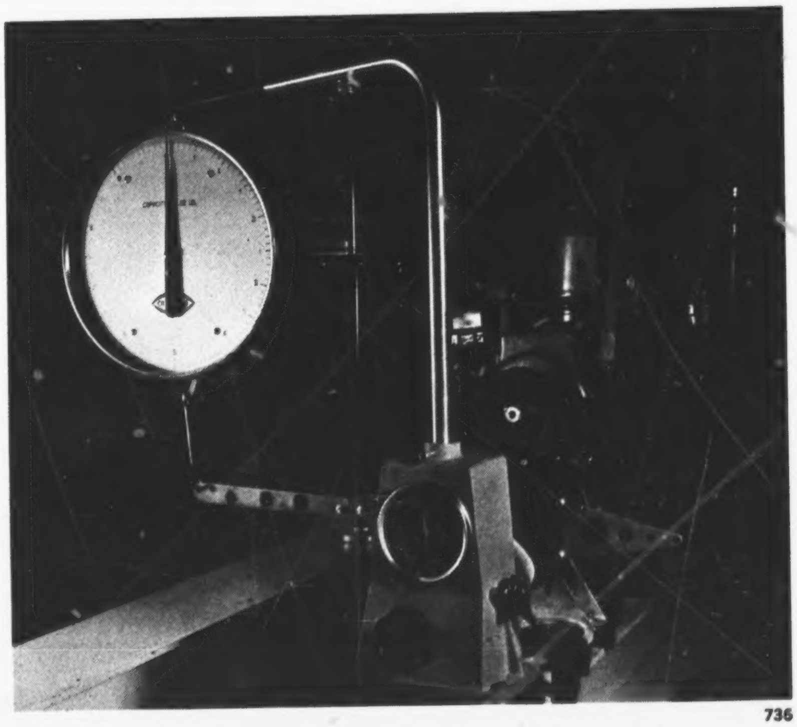
5. *Lock solenoid lever in extreme "closed" position.*

   Some chokes have special provisions for doing this. See your service manual.

6. *Loosen clamp on solenoid arm.*
7. *Adjust choke valve to close.*
8. *Tighten clamp.*
9. *Check for proper operation.*

ADJUSTING THE HIGH-SPEED LOAD VALVE

The valve that controls the fuel-flow for full load at high speed is known by such names as "main adjusting needle," "power adjusting needle" and "high-speed-load adjustment." All refer to the same adjustment — the ones shown in Figures 116 and 117.



736

FIGURE 122. A dynamometer connected to the power shaft of a small engine can be used for providing a load to the engine for carburetor adjustment.

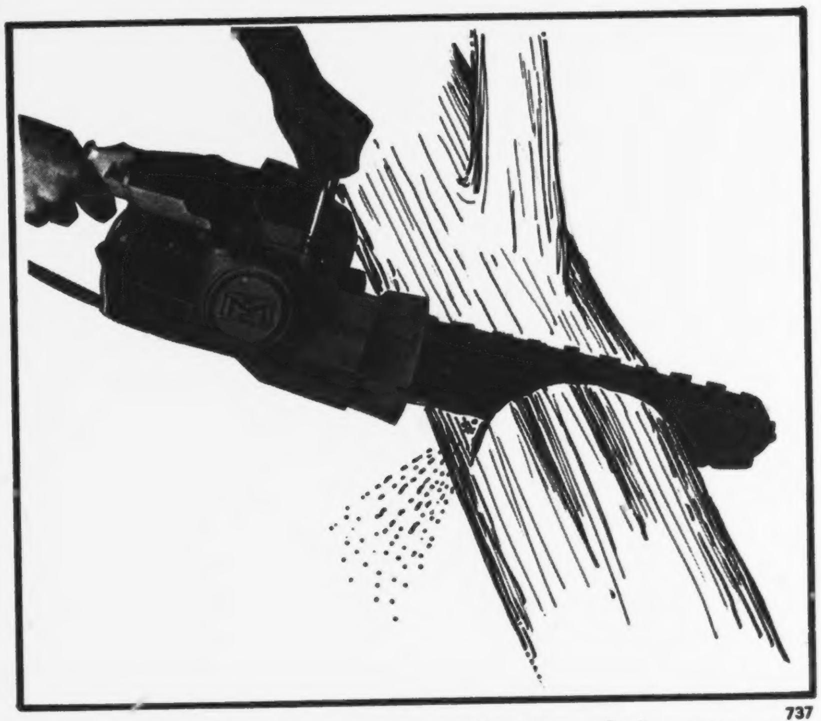
It is particularly important that the engine be up to full operating temperature when this adjustment is made. If it is not, your adjustment will not be satisfactory after the engine reaches normal operating temperature.

1. *Run engine at full throttle, load if possible.*

   If you can **provide a constant load without having your equipment in motion** — such as by belt power take-off or a dynamometer (Figure 122) — you can get a more satisfactory adjustment.

   If you **make adjustments without load,** follow up with a final check to make sure adjustment is satisfactory under load.

   Chain saws should always be checked under normal sawing conditions (Figure 123).



737

FIGURE 123. The best way to check a chain saw carburetor is under actual sawing conditions.

2. *Add load until speed decreases slightly from its high idle speed.*

   Manufacturers recommend that vertical shaft mowers, when operated without the blade, should have a 4-pound balanced weight on the crankshaft to take the place of the weight of the blade for balance.

3. *Turn load adjusting screw clockwise until engine begins to lose power.*

   This indicates that you have reached the border line on the lean side of the mixture as shown by line A in Figure 124. Note that if you leave the adjustment in this position, your engine would have high fuel efficiency but would not be developing its maximum horsepower. Exhaust temperature would be at its highest and could lead to burned valves.

4. *Turn adjusting screw counterclockwise until engine gives off black smoke from exhaust.*

   The adjustment is now providing too rich a fuel-air mixture. Note in Figure 124, line B, that you may be getting satisfactory horsepower, but the fuel efficiency of your engine is somewhat lower. The best adjustment is in between lines A and B.

5. *Turn screw clockwise until engine runs smoothly and at full speed.*

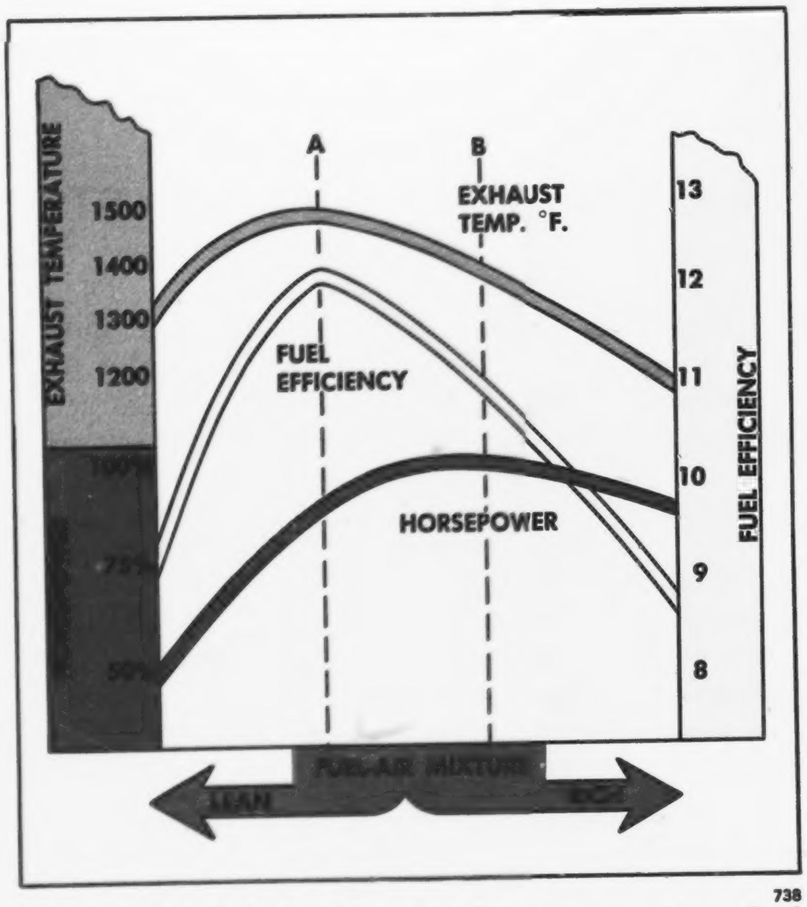
   Make 1/8 turn on needle and wait for engine to adjust.

6. *Check carburetor adjustment by accelerating engine quickly while it is under load.*

   The engine should accelerate quickly when you adjust the speed control lever suddenly if the carburetor is properly adjusted.

   Backfiring indicates too lean a mixture, and **dark colored smoke** indicates too rich a mixture.

   If your engine will be **operating under a heavy load** or during cold weather or both, adjust the fuel-air mixture so it is slightly on the rich side — about 1/16 turn. Do not overdo it. This adjustment is not to take the place of your choke for cold weather starting.



738

FIGURE 124. Relationship of exhaust temperature, fuel efficiency and horsepower to different fuel-air mixtures.

ADJUSTING THE IDLING VALVE

Some manuals indicate an initial setting of 3/4 to 1½ turns open. You should use the one that applies to your particular engine. This is used when your engine will not start because of carburetor trouble and when you are repairing the carburetor. A somewhat finer adjustment, however, may be secured by using the procedures that follow.

1. *Warm the engine if it is not already warm.*
2. *Loosen idle-speed stop screw.*

   Set engine throttle to the slowest speed without stalling.

3. *Tighten idle-mixture screw slowly until engine begins to "roll" or slow down.*

   Use 1/8 turn when adjusting the needle valve.

   After each 1/8 turn, wait a few seconds until the engine has a chance to adjust to the new fuel mixture.

4. *Turn adjusting screw back slowly until engine runs smoothly.*

   If you find that the engine is not affected by one or two complete turns of the adjusting screw, this may indicate trouble — a leaking float valve or diaphragm, too high a fuel level in the float chamber or deposits in the manifold around the throttle valve which are restricting air flow.

5. *Recheck high-speed load adjustment.*

   Refer to previous heading.

   Adjusting the idle speed may change the fuel mixture enough to affect the original adjustment.

6. *Recheck idle-mixture adjustment.*
7. *Check for proper operation.*

   Operate the throttle back and forth a couple of times to see if your engine will accelerate properly from the idle position.

8. *Adjust the idle-speed stop screw.*

   See procedures under next heading.

ADJUSTING THE IDLE-SPEED STOP SCREW

Adjusting the idle speed is really a throttle stop adjustment. A spring on the throttle valve tends to keep it closed. A set screw is provided to act as a bumper to the throttle stop lever. The set screw is called a "bumper stop screw." It can be adjusted to hold the throttle at the desired engine speed.

A spring is usually installed on the screw to hold it in place. Over a period of time, however, this screw will gradually work out. This allows the engine to idle too slowly and may cause it to stop when the speed-control lever is completely retarded. The idle speed may need adjustment when you change from cold weather operation to warm weather operation and vice versa. A difference in altitude will also affect the carburetor adjustment.

The idle speed of small engines is relatively fast. It varies from 1200 to 3200 r.p.m. It will be necessary for you to look in your operator's manual for the proper idling speed of your engine. Most of them recommend approximately 1800 r.p.m. or ½ maximum operating speed. Never get the idea that you are taking care of your small engine by operating it at a slow idle speed. Small engines are designed to operate at full throttle, and the fuel-air mixture is too rich for slow speed. Unburned fuel will foul the spark plugs.

1. *Operate at about half throttle for 2 minutes for warm-up.*
2. *Set speed-control lever at completely retarded position.*

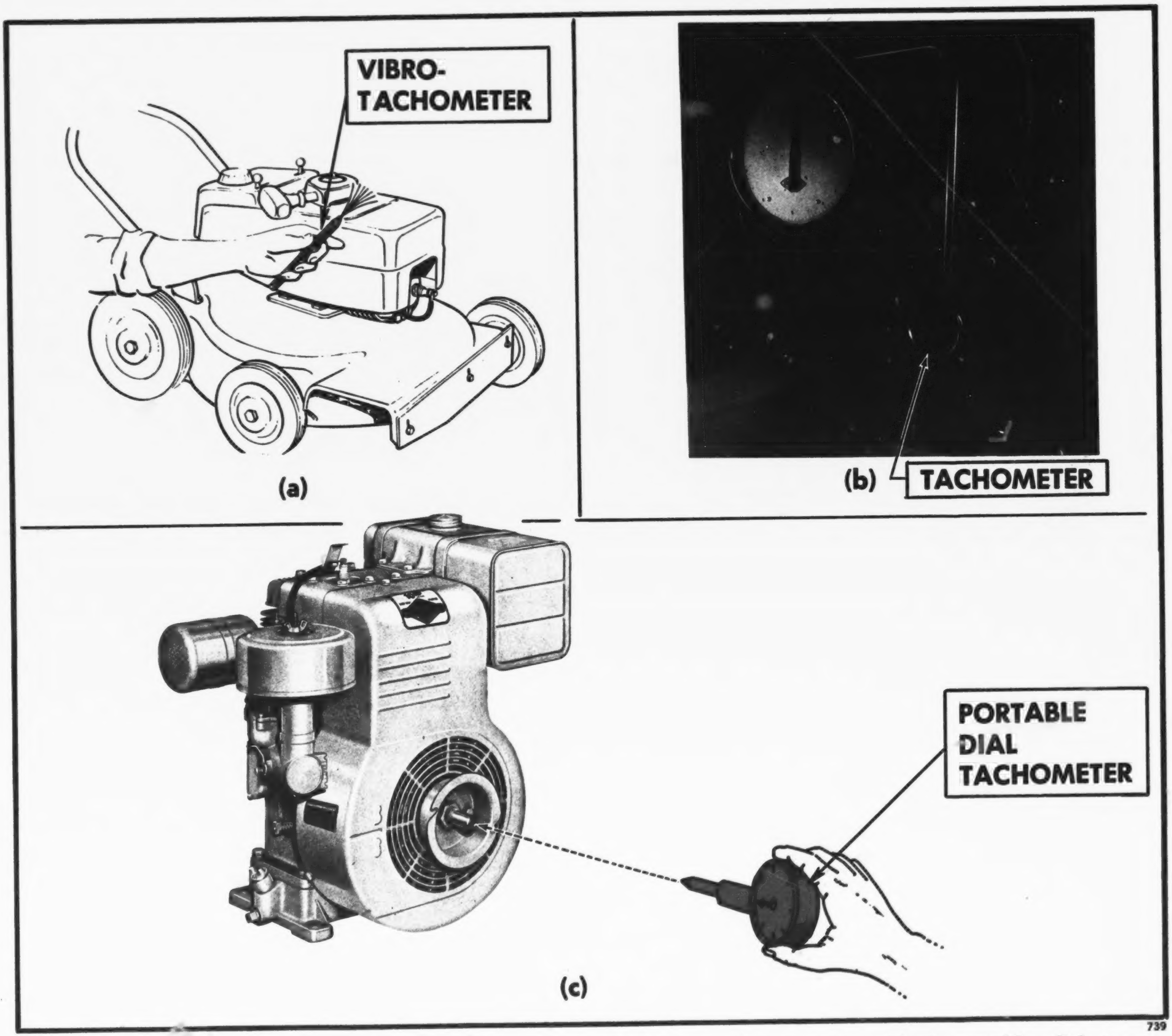


FIGURE 125. (a) A Vibro tachometer. Rest instrument on engine cowling. (b) A dial-type tachometer connected to a dynamometer. (c) A portable dial type tachometer is pressed against the end of the crankshaft.

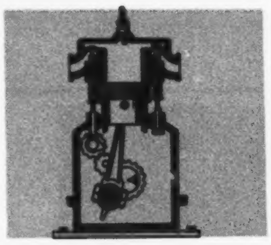
3. *Check the idle speed with a tachometer (Figure 125).*

4. *Adjust to normal idling speed.*

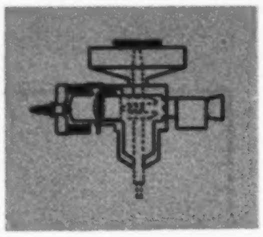
Turning the adjusting screw clockwise usually increases engine speed. Turning it counterclockwise decreases it.

Check your operator's manual for proper idle speed.

NOTE: If after making the carburetor adjustments, there is still evidence of carburetor trouble, refer to procedures in Volume II, "Repairing Carburetors."



J. CHECKING COMPRESSION



How compression is developed in small engines is described under "How Small Gasoline Engines Work," page 10.

Compression should be checked every 50 hours of operation, or more often if your engine is hard to start or if it seems to be losing power.

A simple test is given here for checking the compression. This test can be performed on most small engines. Procedures for more accurate tests are given in Volume II.

One reason procedures are given here for checking the compression in your engine is that if you continue to operate your engine when the compression is low, damage to the engine parts will increase rapidly. Fuel and oil consumption will increase, and the engine will become more difficult to start.

Good compression is necessary for easy starting and the proper operation of your engine. It aids starting in four ways:

- It provides for high pressure and temperatures which are near the ignition point. (The spark plug provides the final spark.)
- It concentrates the fuel mixture into a more restricted space, thus making it easier to ignite.
- It helps to distribute the fuel particles in the cylinder for improved burning.
- The higher the compression, the greater the expansion of gases after the fuel burns in the cylinder. This expansion pressure provides more power to the piston.

Other causes of poor compression are more difficult to correct, such as stuck or burned valves or worn piston rings and cylinders. Procedures for repairing valves, pistons, rings and cylinders are given in Volume II.

Any condition which allows the gases to escape from the cylinder during the compression stroke will cause **poor compression.** You can easily correct some of these conditions, such as a loose spark plug, loose cylinder head bolts, low cranking speed or dry cylinder walls.

Simple procedures for checking the compression are as follows:

1. *Disconnect the spark plug wire to prevent the engine from starting.*
2. *Turn the flywheel by hand until it comes up to compression stroke.*

   If your engine is the 4-cycle type, you should notice a definite resistance at every second revolution of the crankshaft

   If your engine is the 2-cycle type, you should notice a definite resistance on each revolution of the crankshaft.
3. *Give the flywheel a quick twist by hand or with the manual starter.*

   On 4-cycle engines turn the flywheel opposite from the direction of rotation by hand. The reason is that many small engines now have provisions for reducing the compression at low speeds for easy cranking. The compression reducers are not effective when the crankshaft is turning backward.

   If the compression is good, the flywheel will spring back from the force of the compressed air in the cylinder.

   If the compression is poor, there will be little or no resistance to the flywheel turning; neither will it spring back. Proceed to step 4.
4. *Check for cylinder head trouble.*

   Crank the engine and listen for air escaping at the cylinder head. Look for burned spots that are evidences of leaks.

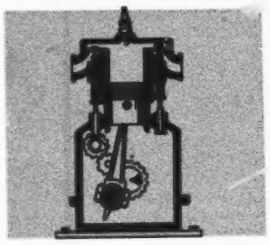
5. *Check for dry piston rings and cylinder walls if your engine has not been operated for several weeks.*

   Sometimes oil will drain from the piston rings while the engine is setting and air will escape by the rings unless they are oiled.

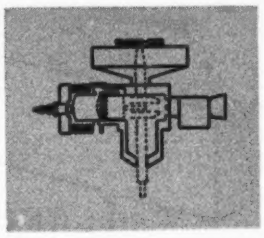
   Remove the spark plug and pour a tablespoon of engine oil in the cylinder. Recheck compression.

   If compression is good, the piston rings are in good condition. The oil provided a seal between the rings and the cylinder wall.

   If compression is still low, check for valve (4-cycle engines), cylinder and piston ring troubles. For procedures refer to "Repairing Valves," and "Repairing Cylinders, and Piston-and-Rod Assemblies," Volume II.



K. CHECKING AND SERVICING BATTERIES



The battery on your small engine supplies electrical energy for (1) the starter (on engines with electric starters) and (2) for igniting the fuel-air mixture in the combustion chamber (on engines with battery ignition) and lights when installed.

Servicing the battery is a simple job for the small engine operator. Perhaps this is the reason it is often neglected the same as automobile and tractor batteries are neglected. In an Illinois study of 60 farm tractors[5], it was found that the batteries in 27 tractors had low liquid levels. Of that number 16 (more than 1/4 of the total) had liquid levels below the top of the plates. Twenty per cent had corrosion on the terminals — evidence that the battery had not been cleaned in recent weeks. No similar studies have been made on batteries used on small engines, but indications are that they are equally neglected.

Your battery will last longer and give better service if you check and service it regularly. Operators' manuals vary in their recommendations as to how often to check and add water. This may be due partly to the liquid capacity of the battery. Another reason is the temperature at which the battery operates. If it is near the engine and is operating in a warm environment, more water will evaporate. Good practices are to check the liquid level weekly and to clean the battery top and connections when they become coated.

How a battery supplies power and procedures for checking and servicing the battery are discussed under the following headings:

1. Functions of the battery and how it works.
2. Importance of proper servicing.
3. Tools and materials needed.
4. Checking and replacing the battery liquid.
5. Checking the battery frame and cable connections.
6. Checking the battery charge.
7. Cleaning the battery.

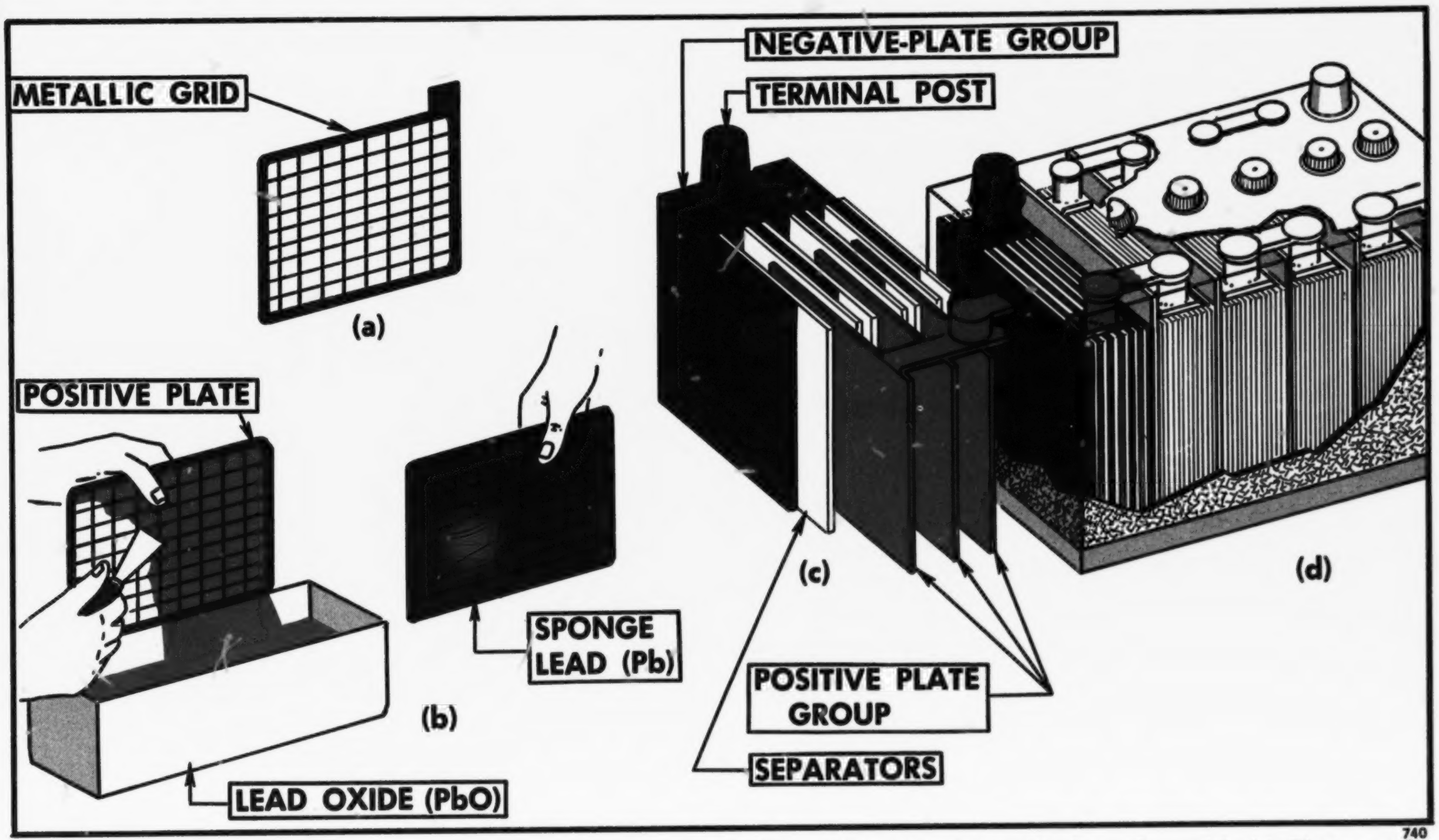


FIGURE 126. Parts of a (lead acid) storage battery. (a) Grid. (b) Lead being added to the grid. (c) Plates and separators. (d) Battery showing cells.

FUNCTIONS OF THE BATTERY AND HOW IT WORKS

To care for a battery you need to understand its construction and how it works. Figure 126 shows the parts of a battery and how they are assembled.

A storage (lead acid) battery contains metallic lead grids (Figure 126a) to which lead oxide is added (Figure 126b). The plates are electrochemically treated in a dilute solution of sulfuric acid. This treatment causes the lead to oxide (PbO) in the positive plates to convert into lead peroxide (PbO_2). The lead oxide in the negative plates is converted into metallic spongy lead (Pb). Groups of positive and negative plates are assembled alternately with separators between each two plates. The separators are of a plastic or cellulose composition and are not normally affected by the acid (Figure 126c). Each such grouping of positive and negative plates forms a 2-volt "element" when immersed in sulfuric acid. Each element is assembled in a hard rubber or plastic "cell" (Figure 126d). The elements are connected in series (positive to negatives plates) by means of welded-on lead connectors. A battery of 6 such cells gives a nominal voltage of 12.

Figure 127 shows how a battery works. The chemical action is shown in the following chemical equation:

$$Pb + PbO_2 + 2H_2SO_4 \underset{\text{charging}}{\overset{\text{discharging}}{\rightleftharpoons}} 2PbSO_4 + 2H_2O$$

The left side of the equation shows a battery cell in a *charged condition.* The right side shows a cell in a *discharged condition.*

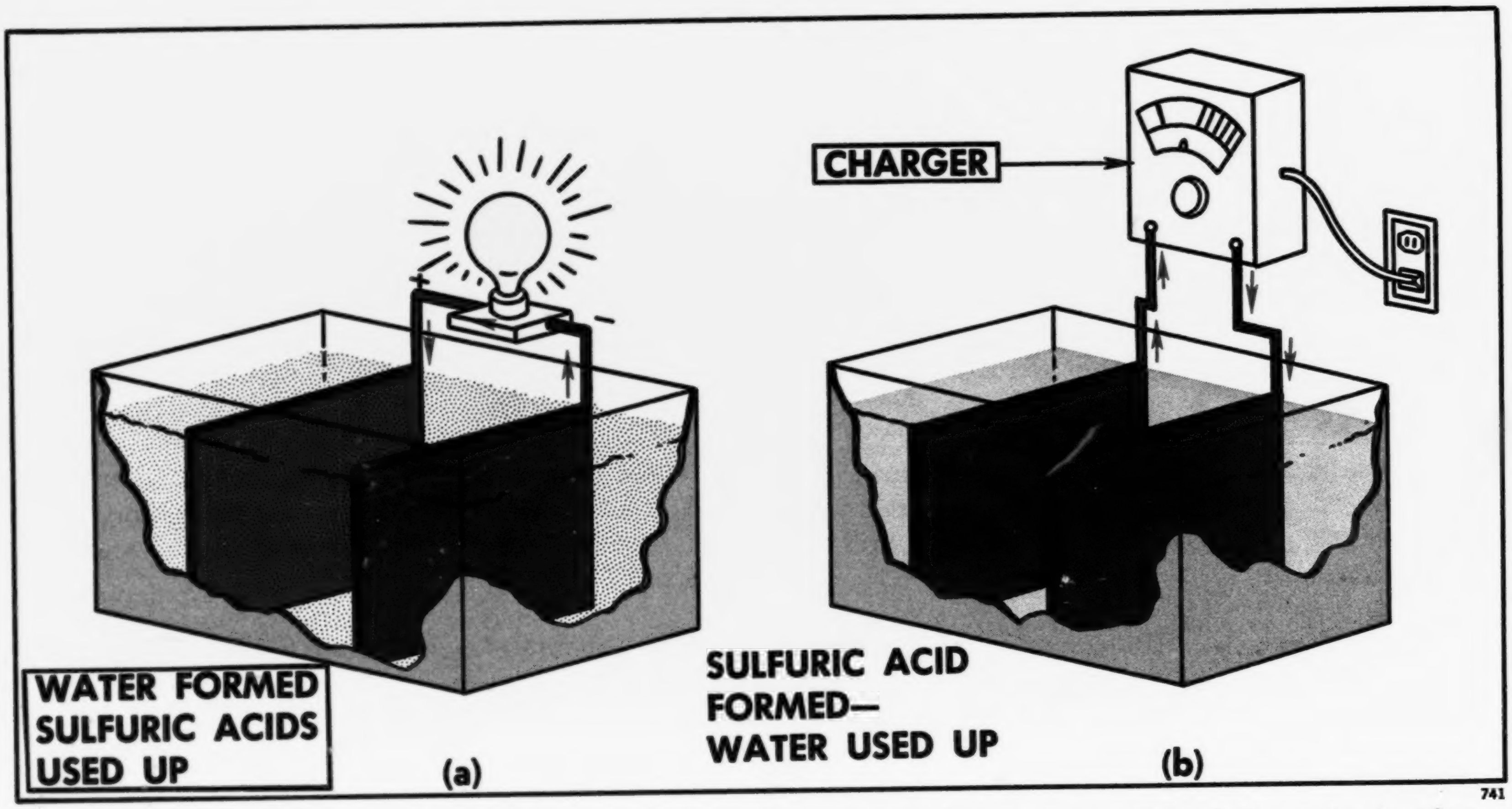


FIGURE 127. How a battery works. (a) While a battery is supplying power, a portion of the sulfuric acid is taken from the electrolyte; water is returned as a result of the chemical reaction. (b) As the battery is recharged, the opposite happens—a portion of the water is taken from the electrolyte and sulfuric acid is returned. (Electrolyte is about 36 per cent sulfuric acid and 64 per cent water when first added to the battery.)

In the **charged condition** the positive plate contains lead peroxide (PbO_2), and the negative plate is composed of sponge lead (Pb). The liquid in the battery is called "electrolyte." It contains about 36 per cent sulfuric acid (H_2SO_4) and 64 per cent water.

When you use energy such as for lights or engine starting, the electrolyte reacts with the sponge lead on the negative plate and the lead peroxide on the positive plate (Figure 127a). *Lead sulfate forms* on both the positive and negative plates. *The acid content of the electrolyte becomes less* and less because it is used in forming lead sulfate ($PbSO_4$). *The specific gravity of the electrolyte decreases* from approximately 1.275 when fully charged to 1.150 when discharged.

If you do not recharge the battery, a point is reached where so much of the active material has been changed into lead sulfate that the cells can no longer produce sufficient current to be of practical value. At this point the cells are said to be "discharged."

In the **discharged condition** both plates contain lead sulfate ($PbSO_4$), and the electrolyte is largely water. Recharging is accomplished by forcing electric current through the battery in the opposite direction from normal battery current flow. This causes the lead sulfate and water to change back to lead, lead peroxide and sulfuric acid as shown on the left side of the chemical equation.

The *sulfuric acid does not need to be replaced* unless it is lost through leakage or is spilled from the battery.

The water is lost partly from evaporation but mostly through chemical action within the battery while it is being charged. It is then that some of the water in the electrolyte is changed to hydrogen and oxygen gases. These pass out the vent holes in the battery caps. If the water is not added to replace the amount that is lost, the tops of the plates become exposed.

IMPORTANCE OF PROPER SERVICING

Operators' manuals warn that you should **maintain the battery liquid level above the level of the plates.** Here is the reason. When portions of the plates and separators are exposed to air, they dry out. Those portions that dry lose their ability to function and may become permanently damaged. Consequently, your battery loses that much of its capacity, which means less power for cranking. It also means shorter battery life since water only is lost through evaporation and forming of gas. The electrolyte remaining becomes very strongly concentrated and may break down the separators and plates (Figure 126) during the time the liquid level is low.

Your battery will *require more water* (a) when it is being overcharged or (b) when the weather becomes hotter.

Some batteries are advertised as requiring water only a few times a year. They do not use less water than other batteries, but they provide more space above the plates for reserve electrolyte. Any battery will last longer, however, if the water level is maintained near the top.

It is important that you *maintain your battery at or near full charge.* There are two reasons: First, when a battery remains discharged for several weeks, *the lead sulfate on the positive and negative plates become hard.* This is called harmful "sulfation." When recharging is attempted, the hardened lead sulfate remains and prevents the plates from taking a full charge. This lowers the overall electrical capacity of your battery and shortens its life.

Second, the capacity of your battery for cold weather starting is greatly reduced. Even a fully charged battery at 0°F. has only 40 per cent of the capacity it has at 70°F. That is the reason a weak battery may give fair service until the weather turns cold. Then it appears to go bad all at once.

Checking the specific gravity, or state of charge, of the battery is recommended for every 50 hours of use. Keep liquid level above the plates and separators. Charge the battery after each water addition and keep it charged. A fully charged battery will not freeze.

The last point is particularly important if you are using a 12-volt battery. It may have a high enough charge to crank the engine but still have low enough charge (weak acid) to freeze.

Cleaning the battery is important. As you use the engine, dirt, moisture and acid gradually accumulate on top of the battery. Acid spray is carried out of the battery with the gas that is liberated while the battery is being charged. It settles on the battery top and provides a damp surface where dust and dirt will cling. It also gets on the battery posts and terminals and equipment and causes corrosion (Figure 128).

The amount of acid present is very small, but it is enough to provide an electrical path to the metal frame or to the opposite terminal. The battery will then slowly discharge itself. With 12-volt batteries

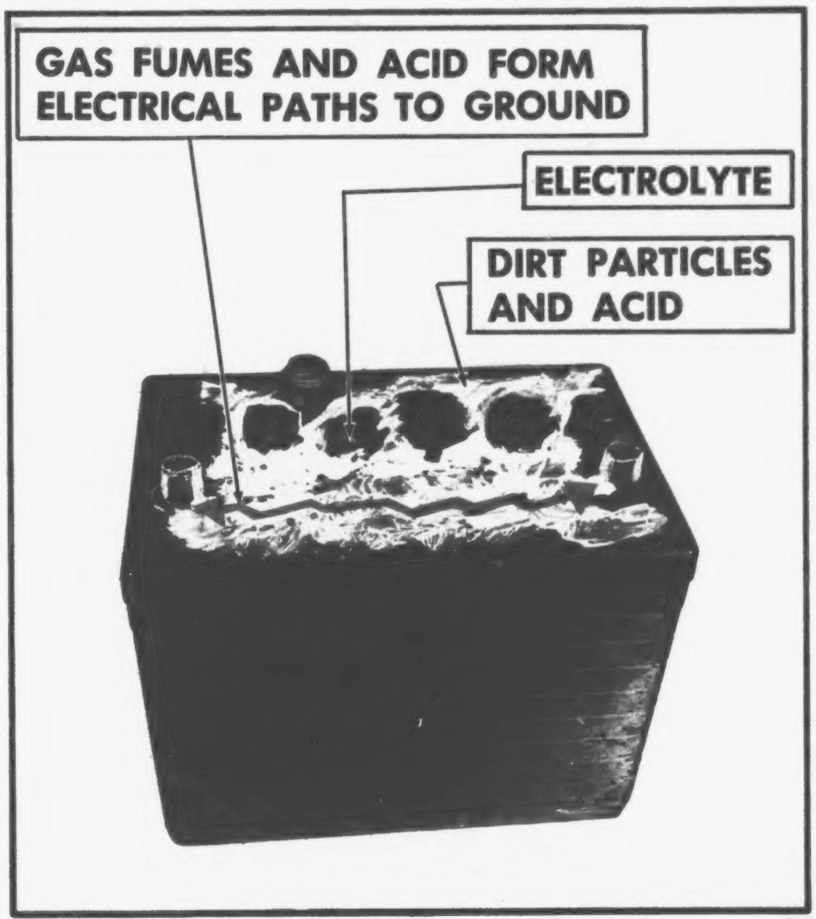


FIGURE 128. Gases that develop when battery is being charged, carry acid as they escape from vents in battery caps. Acid settles on battery top and may accumulate enough to provide electrical paths to ground. This causes a battery to lose its charge and causes corrosion of the cable terminals, carrier and to part of the equipment.

the discharge is much faster than with 6-volt batteries.

A battery, even if charged but not being used, has a natural tendency to discharge slowly. (At 0° F. a fully charged battery may last a year before it becomes completely discharged. At 125° F. the discharge period may be shortened to a month.) If acid and corrosion have collected on top, it will discharge much faster.

TOOLS AND MATERIALS NEEDED

1. Battery syringe
2. Slot-head screwdriver, 8″
3. Box-end wrenches, 7/16″, ½″, and 9/16″
4. Wrenches that fit nuts on battery hold-down clamp and nuts on battery posts
5. 0 - 20 direct-current voltmeter
6. Wire brush and sandpaper
7. Small paint brush
8. Battery clamp puller
9. Jar of clean water
10. Battery hydrometer
11. Baking soda
12. Container with about 1 pint of water
13. Light grease (petroleum jelly)
14. Bristle brush

CHECKING AND REPLACING THE BATTERY LIQUID

If you have reason to believe that your battery has a low charge, follow procedures under "Checking the Battery Charge," page 117.

If your battery has been giving satisfactory service, proceed as follows:

1. *Remove caps from battery cells* (Figure 129).

   Most caps are threaded. Some are pressed into position. Turn them upside down and lay them on the side of the battery case. This keeps acid off the battery top.

CAUTION! Do not smoke or light a match while the caps are removed (Figure 130). If the battery has been charging, hydrogen gas is present. A concentration as low as 7 per cent may burn or explode in the presence of a spark or flame and spatter acid all over you.

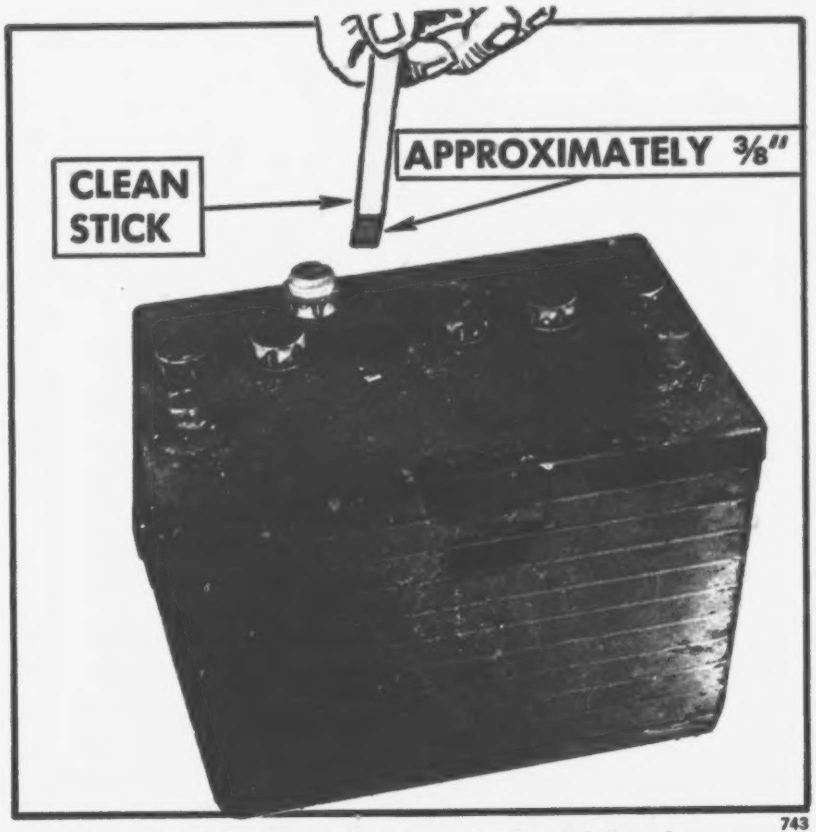


FIGURE 129. Checking the battery liquid level.

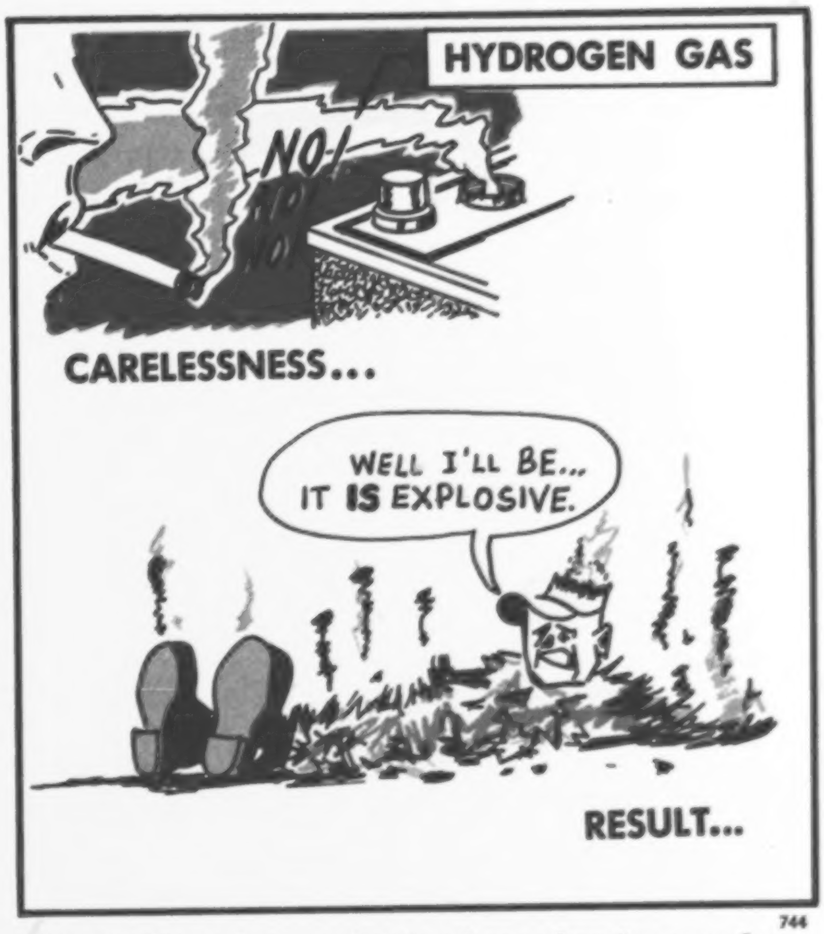

HYDROGEN GAS
NO! NO! NO!
CARELESSNESS...
WELL I'LL BE... IT IS EXPLOSIVE.
RESULT...
744

FIGURE 130. A battery that has been charging may have enough hydrogen gas present to cause an explosion or fire in the presence of a spark or flame. It usually breaks the battery case.

2. *Fill each cell to fill level with clean water (Figure 131).*

Use distilled water whenever possible; otherwise, clean tap water may be added.

In many batteries the vent well (Figure 131) extends into the battery far enough for the lower end to serve as a *fill level indicator* Batteries without this arrangement are usually filled until the level of the electrolyte is about 3/8 inch above the level of the separators. A battery syringe is best for filling (Figure 131).

Avoid overfilling. If the level is too high, when the battery heats, the electrolyte will overflow through the caps and onto the top of the battery. As the electrolyte spreads, it may reach the battery terminals and the battery frame. It then provides a path for leakage of electricity and also causes corrosion and deterioration of the metal parts.

CAUTION! Wear safety glasses to protect your eyes from acid when servicing the battery.

CAUTION! If acid does splash on you, wash it off with lots of cold water as soon as possible. If it gets into your eyes, splash them with cold water. See a doctor.

3. *Replace caps on battery.*

If operating under dusty conditions, check the vent hole in the cap to make certain it is not filled with dirt. If clogged, clean with water and replace caps on battery.

If the vent is plugged, enough pressure can develop in the battery to break the seal or case.

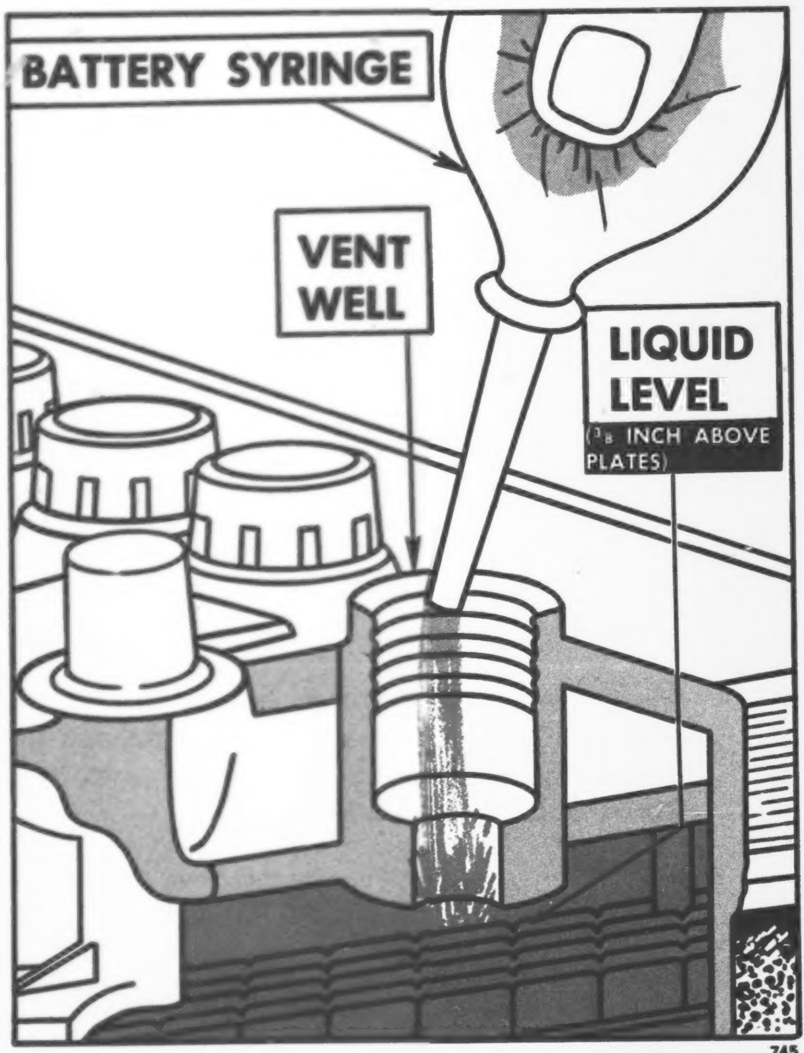


FIGURE 131. Add water until electrolyte reaches bottom of extended vent well or until liquid level is approximately 3/8 inch above plates.

CHECKING THE BATTERY FRAME AND CABLE CONNECTIONS

Check for loose terminal connections on the battery posts and for loose hold-down clamps on the battery.

If the terminals are loose, there is resistance to the flow of current at this point so that equipment supplied by the battery does not get the full benefit of the battery voltage.

If the *hold-down clamp is loose,* the battery is free to bounce which in turn may damage the plates and can cause internal short circuiting. It is also possible to tighten the hold-down clamps too much and put the battery in a bind which can result in breaking the case. Tighten just enough to prevent movement of the battery.

If there is corrosion on the battery terminals, proceed with "Cleaning the Battery," page 121.

CHECKING THE BATTERY CHARGE

Some people think they can test a battery with a pair of pliers or a screwdriver. They "short" across the two terminal posts to see if there is a spark.

This method is hard on the battery. It is also dangerous. If hydrogen gas has accumulated around the battery, the spark resulting from the short circuit may cause the battery to explode.

There are two methods of testing your battery: (a) with voltmeter equipment or (b) with a hydrometer. The specific-gravity method (hydrometer) is more commonly used. This is partly because a hydrometer can usually be purchased for approximately $2; yet it does a satisfactory job of testing.

a. **If you use a hydrometer** to test your battery, proceed as follows:

   1. *Remove battery caps.*

      Note the level of the electrolyte in the cells. If it does not cover (the separators), add water and further delay checking until after you have operated your engine about four hours so the water has time to mix into the electrolyte.

   2. *Insert hydrometer nozzle, compress bulb and then slowly release to draw electrolyte into barrel (Figure 132).*

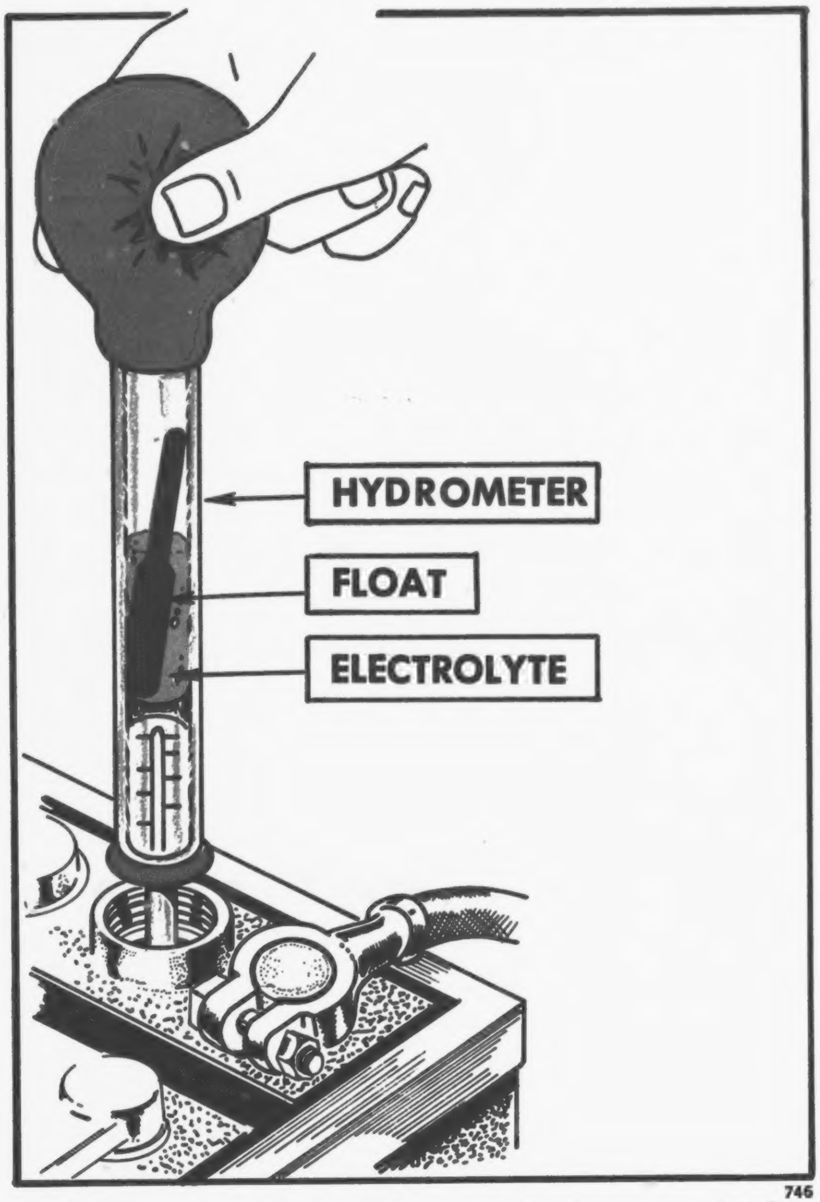


FIGURE 132. Draw electrolyte into hydrometer slowly.

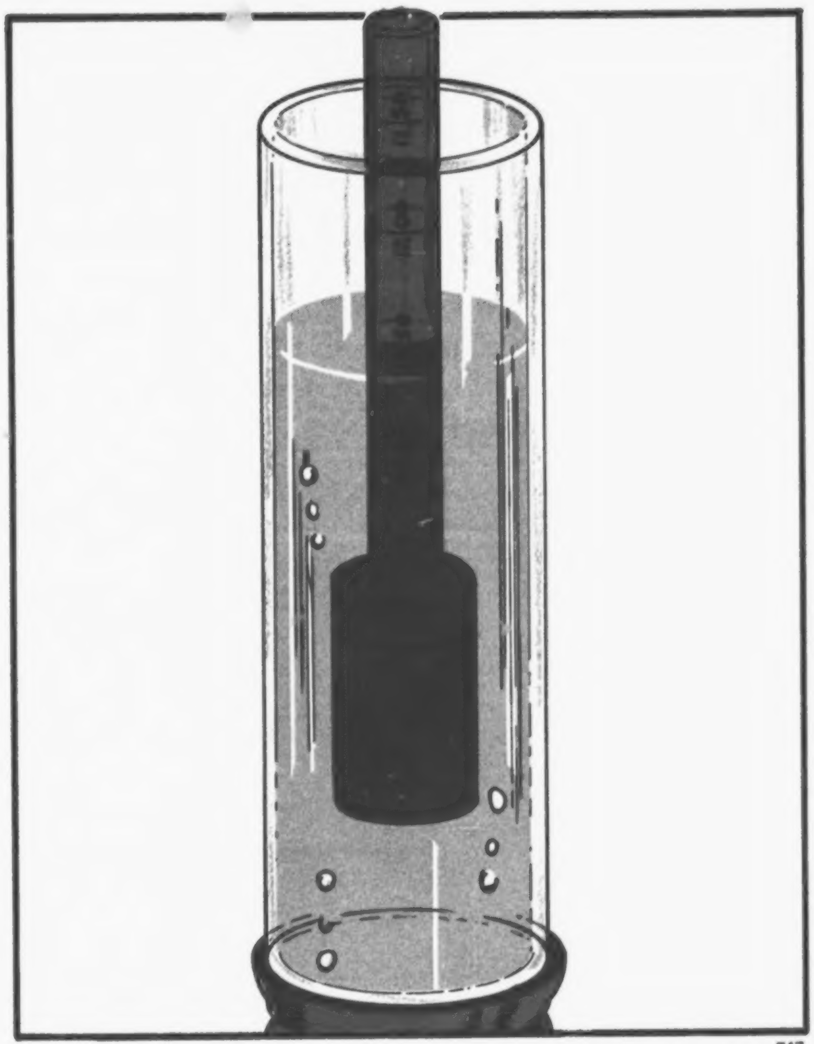


FIGURE 133. Make certain that float rides freely on liquid.

3. *Adjust electrolyte level until float rides freely Figure (133).*
   If the float tends to stick to the side of the hydrometer barrell, shake it sideways gently. *If it still sticks,* flush the inside of the hydrometer with soap and water and rinse with clean water before doing further testing.

   If the paper scale inside the float appears wet, the float probably leaks and your reading will not be accurate.

4. *Hold hydrometer vertically while taking reading (Figure 134).*

   Leave the hydrometer nozzle in the battery cell to avoid dropping acid on the battery and metal parts of the engine or equipment.

   Adjust your position while reading the scale so your eye is level with the liquid (Figure 134). This will improve the accuracy of your reading.

5. *(Take temperature of the electrolyte.)*

   Normally, this step is not necessary. For very accurate readings or readings taken under very hot and especially under very cold conditions, however, you will need to allow for a reading adjustment. This is done by adding .004 for each 10 degrees above 80 degrees, or subtracting .004 for each 10 degrees below 80 degrees F.

   The reason for this adjustment is that as the temperature goes up, the electrolyte expands and is not so dense as at 80 degrees. For example, if you had a quart jar full of electrolyte at 80° F. and warmed it to 125° F., a portion would overflow. What remained would weigh less (be less dense). As the electrolyte cools below 80° F., it becomes more dense; so gravity points are subtracted.

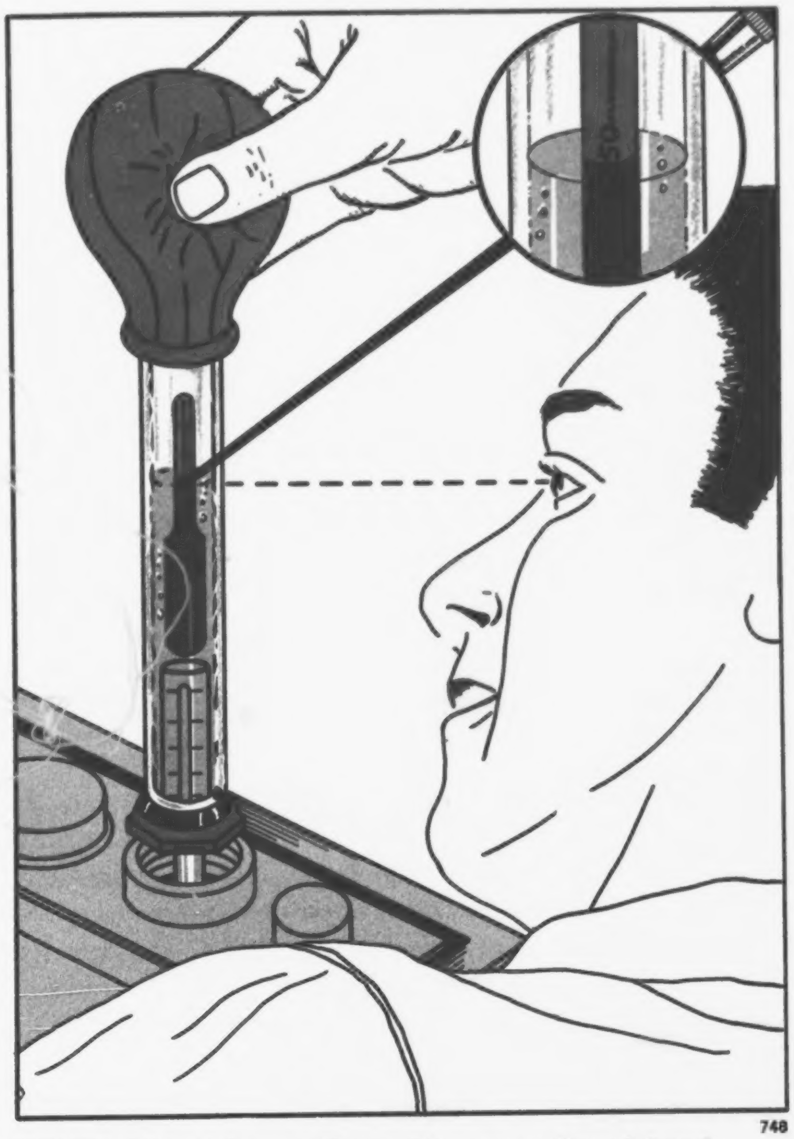


FIGURE 134. Take reading with eye at liquid level.

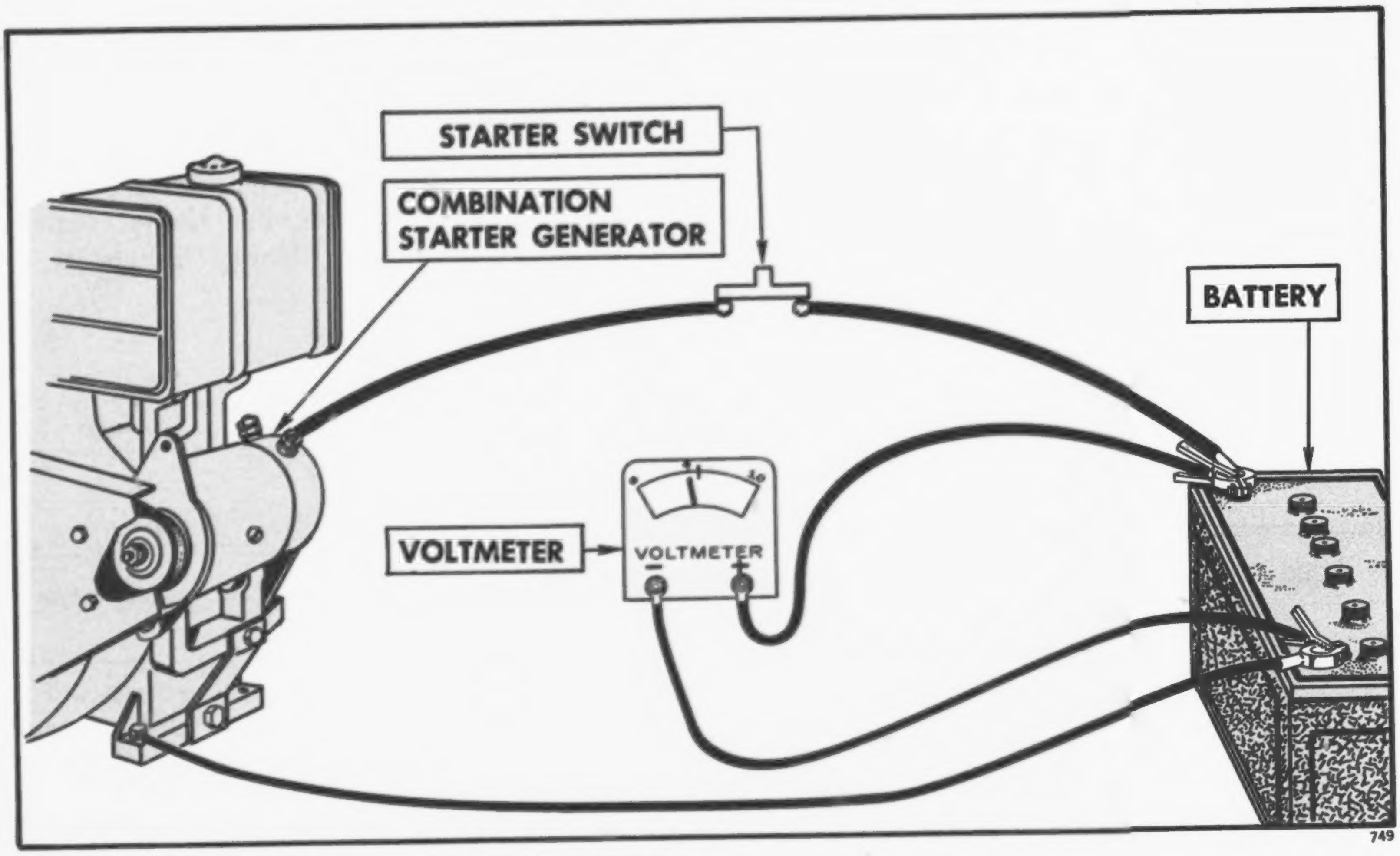


FIGURE 135. Testing the battery voltage with a voltmeter.

By making the corrections your readings are the same as if taken at a temperature of 80° F.

Some hydrometers have a thermometer built into the base of the barrel (Figure 88). If there is no thermometer as part of the hydrometer, you can use an ordinary dairy thermometer and insert it into the battery cell for a temperature reading.

6. *Return electrolyte to cell from which it was removed.*

CAUTION! If you accidentally spill some of the electrolyte on your skin or clothing, rinse with water immediately. Apply baking soda or lime to neutralize the acid.

7. *Check remaining cells in the same manner.*

8. *Flush hydrometer with clear water.*

9. *Interpret results of readings from each of the battery cells from Table IV, page 120.*

b. **If you use a voltmeter*** to test your battery, proceed as follows:

1. *Connect the voltmeter to the battery (Figure 135).*

   Connect the **positive lead of the voltmeter to the positive post of the battery** and the **negative lead of the voltmeter to the negative post of the battery.**

2. *Disconnect spark-plug wire.*

   This is to prevent the engine from starting while the test is being made.

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*A 2-volt voltmeter can be used. With it each cell can be tested. Also, most battery chargers are equipped with voltage and load testers to determine the condition of a battery.

3. *Operate the starter.*

Hold starter switch long enough to get an accurate reading on the voltmeter but not longer than 10 seconds. This is to ease the load on the battery and to keep the starter from overheating.

4. *Read voltmeter.*

If the voltage is less than 9 volts (12 volt system), it is very likely that the battery is in need of recharging or is bad. For checking out the circuit, refer to "Checking and Repairing the 12-Volt Direct-Current Starting Circuit," Volume II.

TABLE IV. INTERPRETING THE BATTERY SPECIFIC GRAVITY READING

Specific Gravity Reading	**What It Means**
1.300	Electrolyte level is low, battery is being **overcharged** and **electrolyte** has been added instead of water.
Between 1.225 and 1.280	Battery is in good condition. Some batteries are fully charged with a reading of 1.280 while others are fully charged at 1.250 or less. Batteries intended for use in warmer climates may be fully charged with the specific gravity as 1.225.
Under 1.225	Battery charge is **too low.** Have it recharged The electrolyte in various stages of charge will start to freeze at the following temperatures: Specific Gravity Reading (Corrected to +80°F.) — Electrolyte Freezing Temperatures 1.250 .... -62°F. 1.200 .... -16°F. 1.150 .... + 5°F. 1.100 .... +19°F.
If there are more than 50 gravity points difference between the highest and lowest cell readings (example: 1.250 high and 1.200 low).	Battery may need to be replaced. Check with your dealer. The condition may indicate: short circuits in the battery; unequal losses of acid from the cells; that the battery is worn out due to loss of active plate materials, break down of the separators, or accumulation of impurities. Battery additives are sometimes offered for sale. They are supposed to rejuvenate worn out or "dead" batteries. Extensive tests by the National Bureau of Standards, have shown that one of those tested are of value.

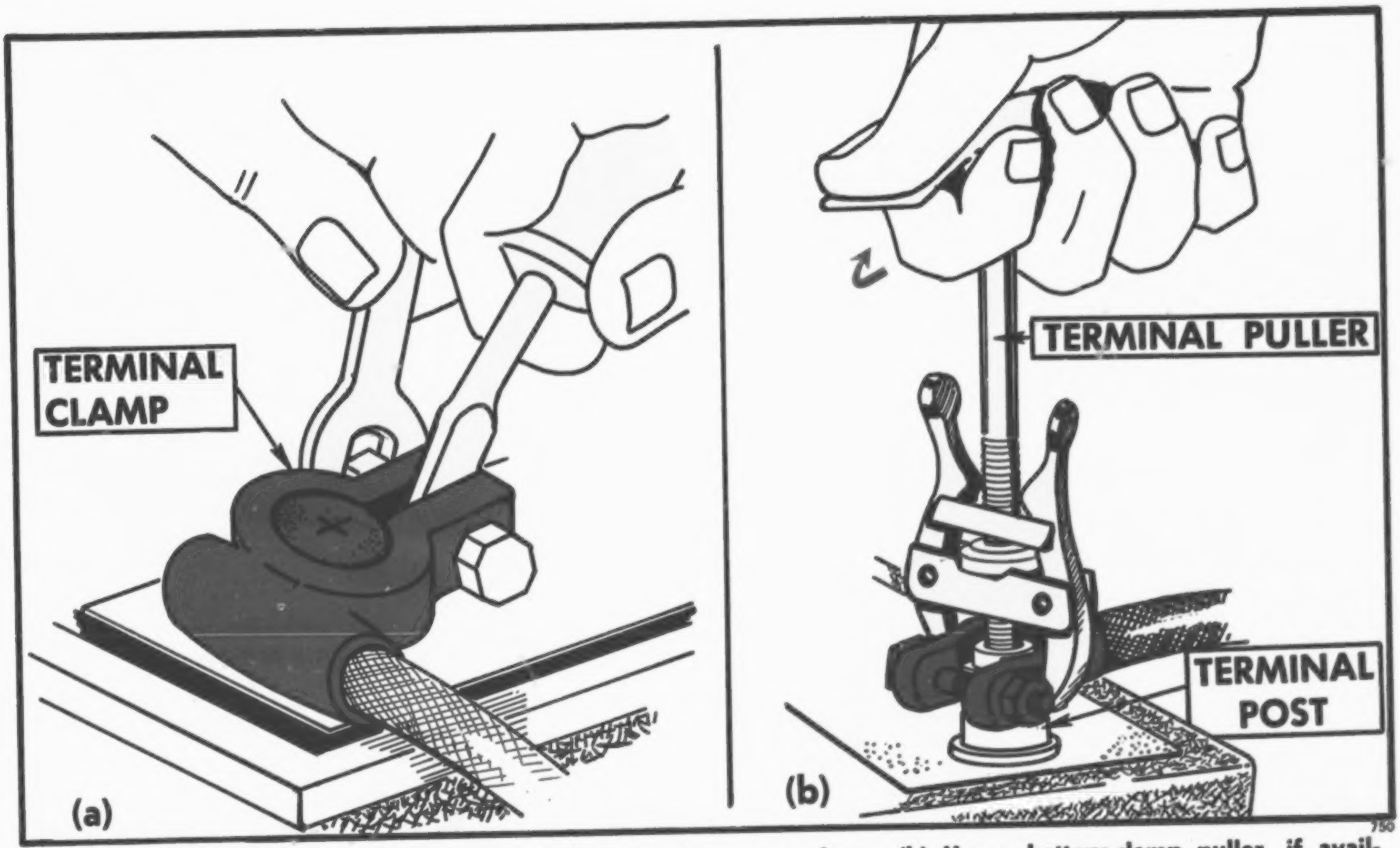


FIGURE 136. (a) Loosen clamp bolt and carefully spread jaws on clamp. (b) Use a battery-clamp puller, if available, to prevent loosening the battery post.

CLEANING THE BATTERY

1. *Disconnect cable and ground strap from battery terminals if they are corroded (Figure 136).*

   Loosen ground strap first. This prevents short circuits in case you accidentally lay a wrench or screwdriver on the battery in such a way as to contact the opposite battery terminal and some part of the frame.

   If you remove the battery, tag the terminal connections so you will know how to reinstall it. If you connect it wrong, there is a danger of burning out the voltage regulator.

2. *Clean cable clamps and battery post (Figure 137).*

   A wire brush (Figure 137a) may be used on outside surfaces. Sandpaper is satisfactory for cleaning inside of clamps. Pay special attention to inside of cable clamps and outside of battery posts. Special battery connection cleaning tools are available (Figure 137b).

   CAUTION! Use safety glasses to protect your eyes when using a wire brush.

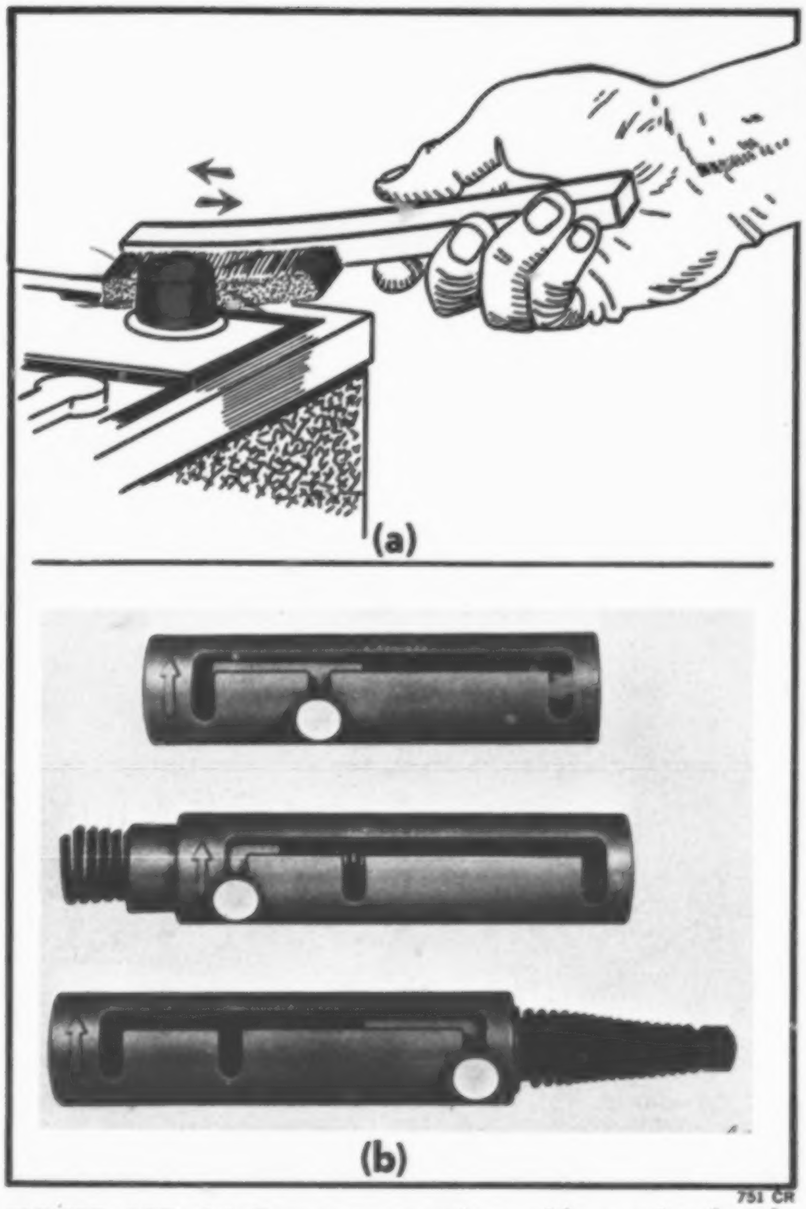


FIGURE 137. (a) Remove corrosion with a wire brush, or (b) use a special tool for cleaning battery post and clamp.

3. *Remove loose dirt and corrosion particles from top of battery Figure 138.*

4. *Brush soda-and-water mixture on top of battery, on posts and on clamps (Figure 139).*

   Use approximately two tablespoons of *baking soda* in a pint of water. Mix thoroughly and apply on the battery. This will react with the acid and cause considerable foaming. Apply until foaming stops.

   Some manufacturers recommend the use of *hot water* with a temperature of 125 to 150 degrees in place of soda and water.

WARNING! Keep water or soda and water from entering the battery through the breather hole in each cap; it will weaken the acid in the electrolyte.

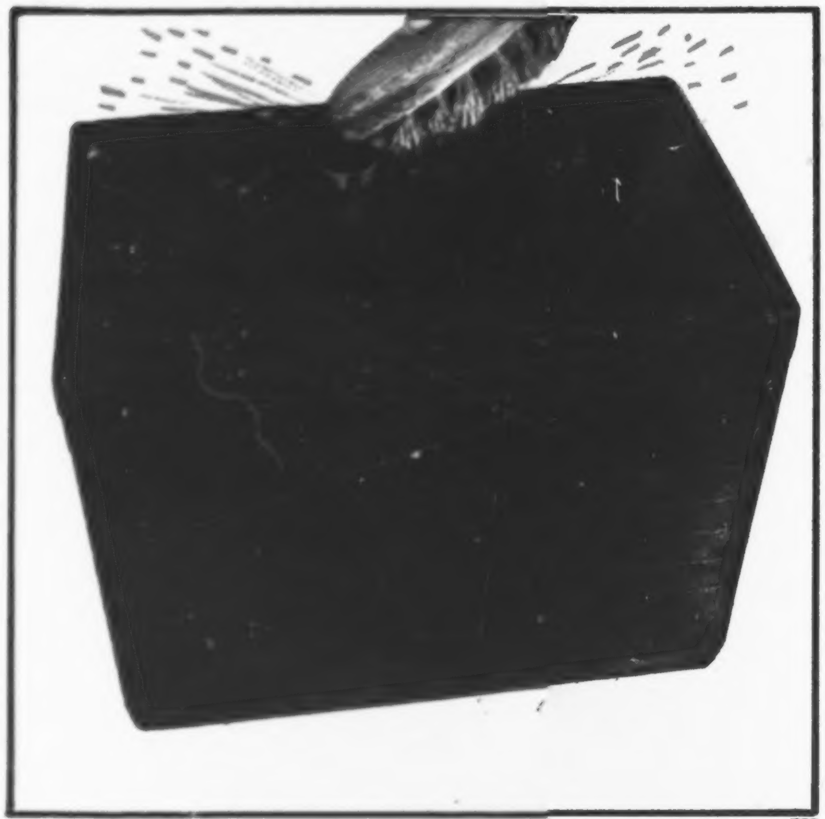


FIGURE 138. Remove dirt with a bristle brush.

5. *Wash away residue with clean water (Figure 140).*

   Remove residue that may have lodged on battery frame or parts of engine and equipment.

   Breather caps may be plugged with toothpicks to prevent water and dirt from going into the battery.

BAKING SODA
& WATER
753

FIGURE 139. Soda-and-water solution reacts with acid and neutralizes it.

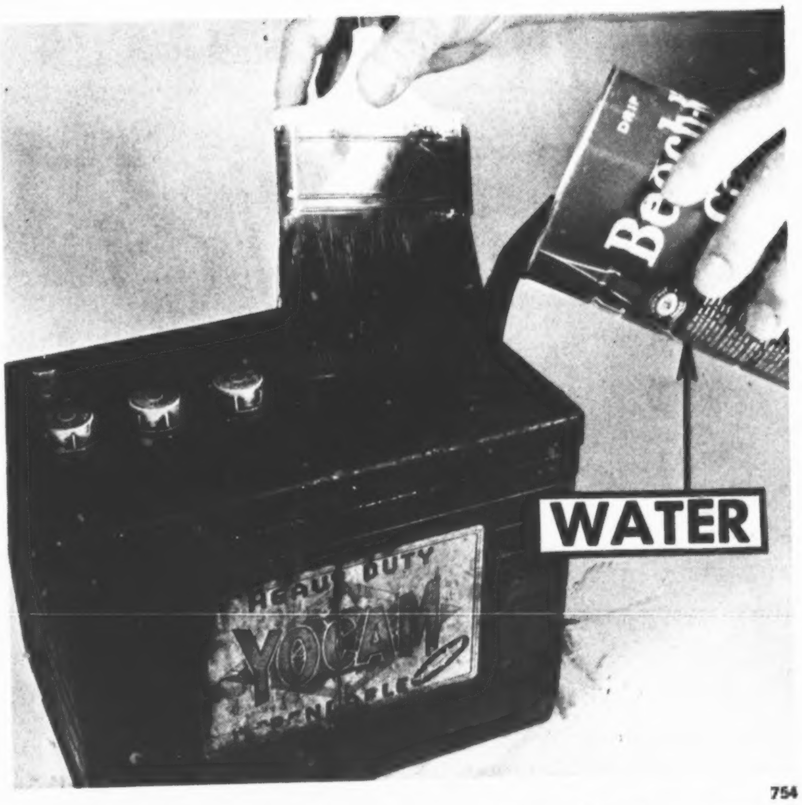


FIGURE 140. Protect battery caps from direct stream of water to avoid flushing dirt or corrosion particles into the battery.

6. *Dry top of battery with a clean cloth.*

7. *Reconnect power cable and ground strap.*

   Connect power cable first to help avoid grounding the battery with your tools.

   Do not hammer the clamps into place on the battery posts. You can break the seal around the battery terminal or cause a crack in the cell cover. In either instance the electrolyte will work out on top of the battery and hasten battery failure.

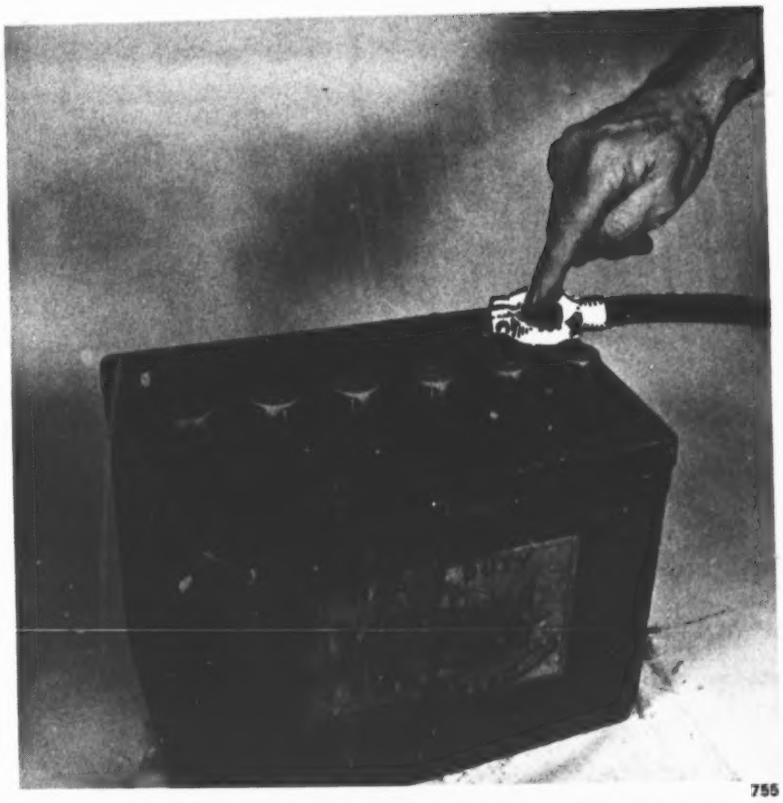
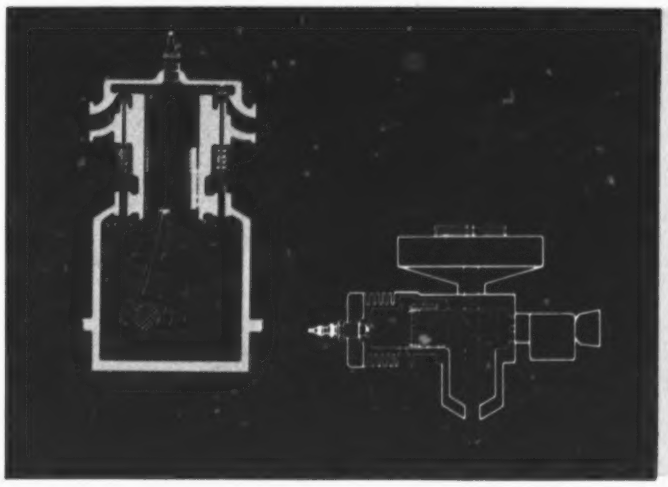


FIGURE 141. Apply grease or petroleum jelly (vaseline) to protect against corrosion.

   If the *jaws of the clamp meet before the clamp tightens* adequately on the battery post, take your knife and cut a small amount of metal from between the jaws.

8. *Apply a coating of petroleum jelly (vaseline) to post and cable-clamp connections (Figure 141).*

   This helps protect against further corrosion.



II. STARTING AND OPERATING ENGINES

Every owner or operator of a small engine should be familiar with — and follow — the proper procedures for starting and operating it.

If you follow the proper procedures, you will save much time and irritation. Also, your engine will last longer and give better service while it lasts.

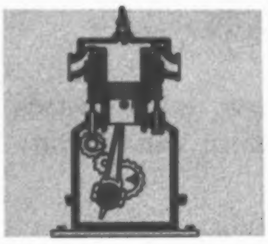
Regardless of how carefully you follow procedures, however, you will encounter troubles once in a while.

It is best to correct a mechanical problem when it first appears. If allowed to continue, one problem will aggravate another and finally result in major difficulties. For this reason you should be able to recognize problems when they arise and be able to take the proper steps for correcting them.

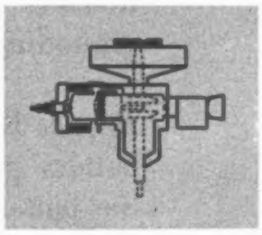
A study of the following discussions will help you become a better operator and a better judge of the cause of starting and operating troubles. The discussions are under the following headings:

A. Starting engines.

B. Operating engines.



A. STARTING ENGINES



Most operators have more trouble starting a small engine than they do with any other phase of operation.

Procedures for starting an engine are discussed under the following headings:

1. Preparing to start the engine.
2. Starting the engine.

PREPARING TO START THE ENGINE

A small engine and the equipment it operates can be dangerous if improperly used.

Read your operator's manual carefully (Figure 142a). Understand how to operate the engine and equipment controls. Learn how to disengage power from implements and how to stop the engine quickly in case of emergency.

Do not wear loose-fitting clothing which may

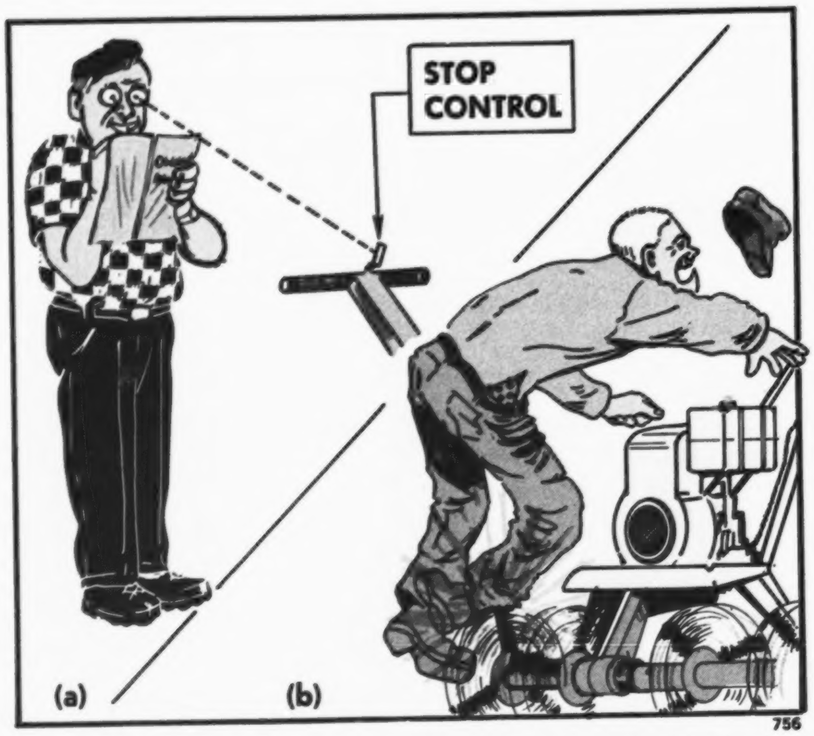


FIGURE 142. (a) Read your operator's manual. (b) Do not wear loose-fitting clothing around equipment, and stay clear of the moving parts while the engine is running.

catch in the moving parts of the engine or equipment (Figure 142b).

Follow these steps in preparing to start your engine:

1. *See that it has been serviced properly.*

   Procedures for servicing are given under "Servicing Small Engines," page 19.

2. *Move the engine and/or equipment outside of any enclosed area (Figure 143a).*

   Exhaust gases contain carbon monoxide, an odorless deadly poison.

3. *See that the area is clean.*

   Gasoline spilled on the floor is a fire hazard. Wash it away with water (Figure 143b).

4. *See that the engine is level and well balanced.*

   There is a danger of pulling the equipment over when using pull-type starters.

5. *Apply brakes if the equipment has them.*

6. *Disengage clutch on all power-driven equipment when possible.*

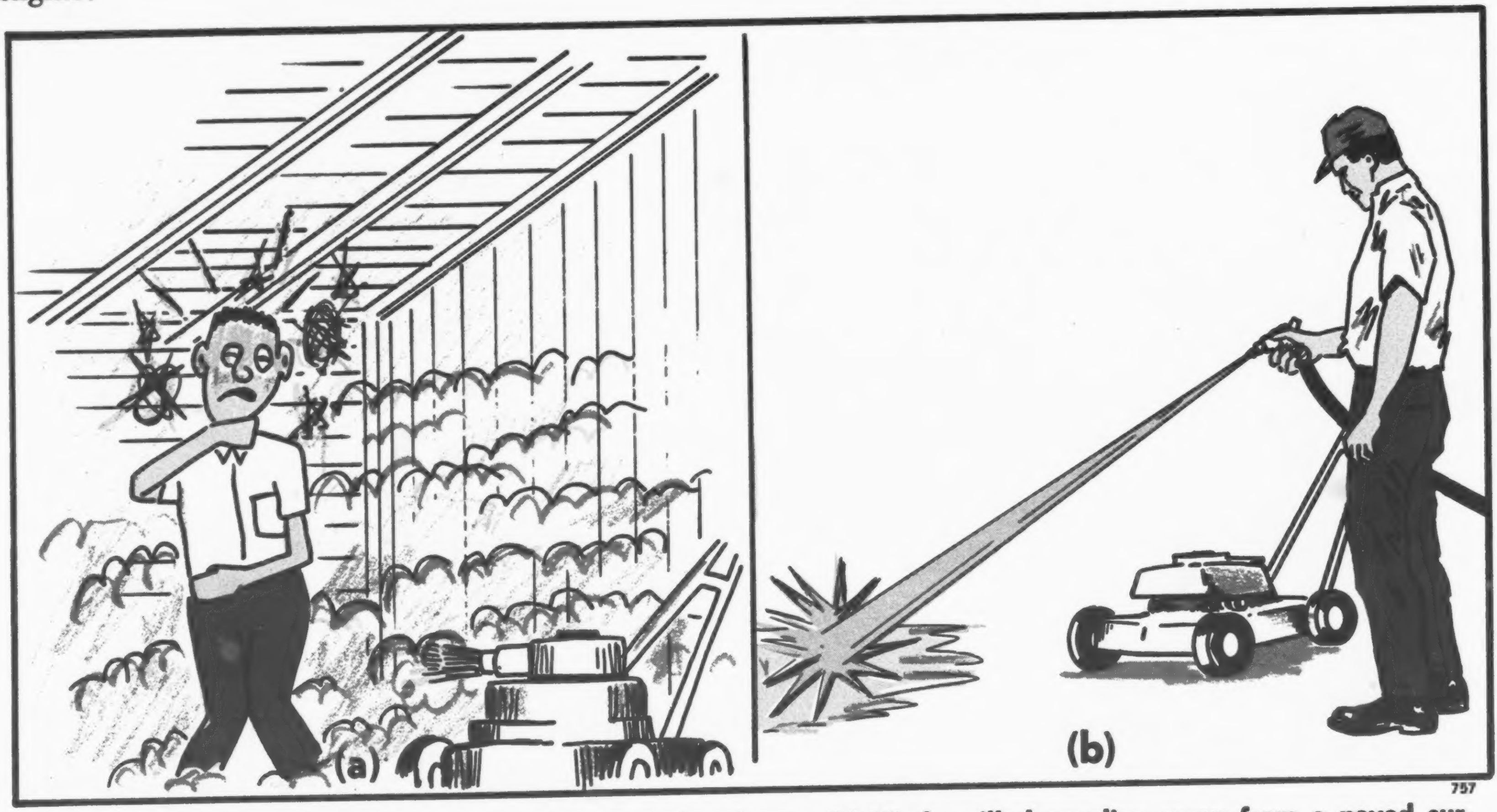


FIGURE 143. (a) Do not operate your engine in a closed area. (b) Wash spilled gasoline away from a paved surface with water before starting your engine.

This relieves the load on the engine during cranking and warm-up. It is also a safety measure.

Some manufacturers of small tractors design them so that they will not start unless the power take-off clutch is disengaged.

7. *(Remove the spark plug and crank engine several times.)*

   This applies only when you are removing the engine from storage.

   This is to remove any excess oil from the cylinder that may remain from storage.

8. *(Adjust carburetor if needed.)*

   Most carburetors are preset at the factory. But some manufacturers recommend checking the adjustments before starting an engine for the first time. Also, readjust the carburetor if you have worked on the carburetor and/or overhauled the engine. See "Checking and Adjusting Carburetors," page 86.

STARTING THE ENGINE

1. *Open the fuel shut-off valve (Figure 144) if your engine is equipped with one.*

   Open valve all the way to prevent leakage around the valve stem.

2. *Close the choke valve or prime the carburetor.*

   Either choking or priming accomplishes the same purpose — that of making available more fuel for vaporization.

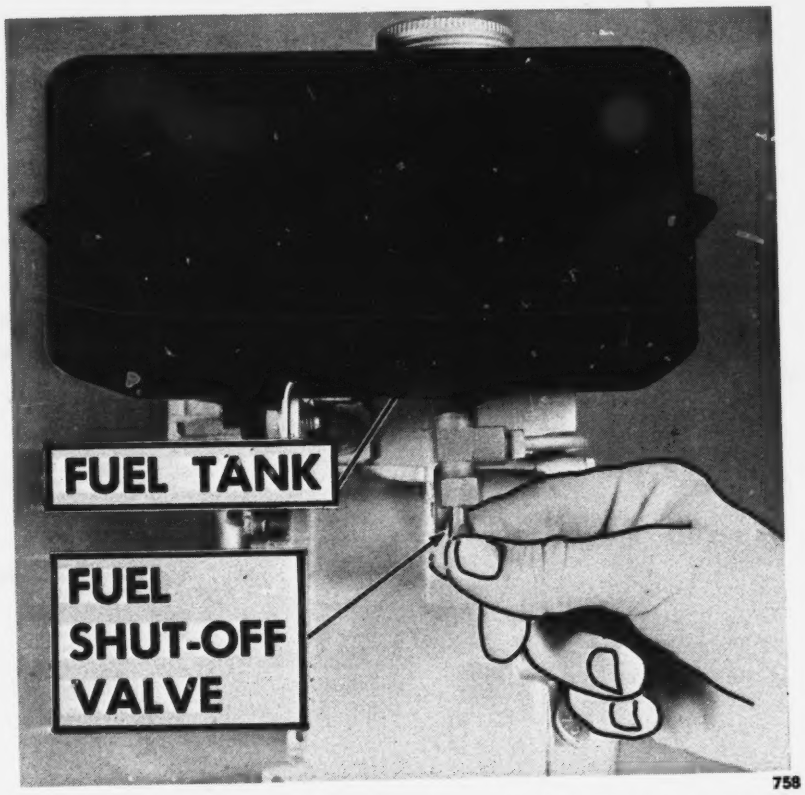


FIGURE 144. Open shut-off valve all the way to prevent leakage around the valve stems.

The choke (Figure 145) helps to increase vaporization by reducing the pressure in the induction system.

Only vaporized fuel will ignite.

There is a wide variety of **choke-control** designs, but, no matter what the design, the operating principle is the same as shown in Figure 145. Figure 146 shows three common types of choke controls.

Usually the choke control is clearly marked. The direction for closing the valve is also marked.

If you are in doubt as to whether the valve is closing or not, remove the air cleaner and look into the carburetor air inlet. Observe the operation of the choke (Figure 147). Replace carburetor air cleaner before attempting to start engine.

Some engines are equipped with a **primer** (Figure 148). The primer is a hand pump which pumps liquid fuel into the carburetor to enrich the fuel-air mixture. Usually one or two strokes of the primer are sufficient. If you have a diaphragm carburetor (Figure 113, page 99), pump the primer until there is a pressure on the plunger. This indicates that the carburetor and lines are full of fuel.

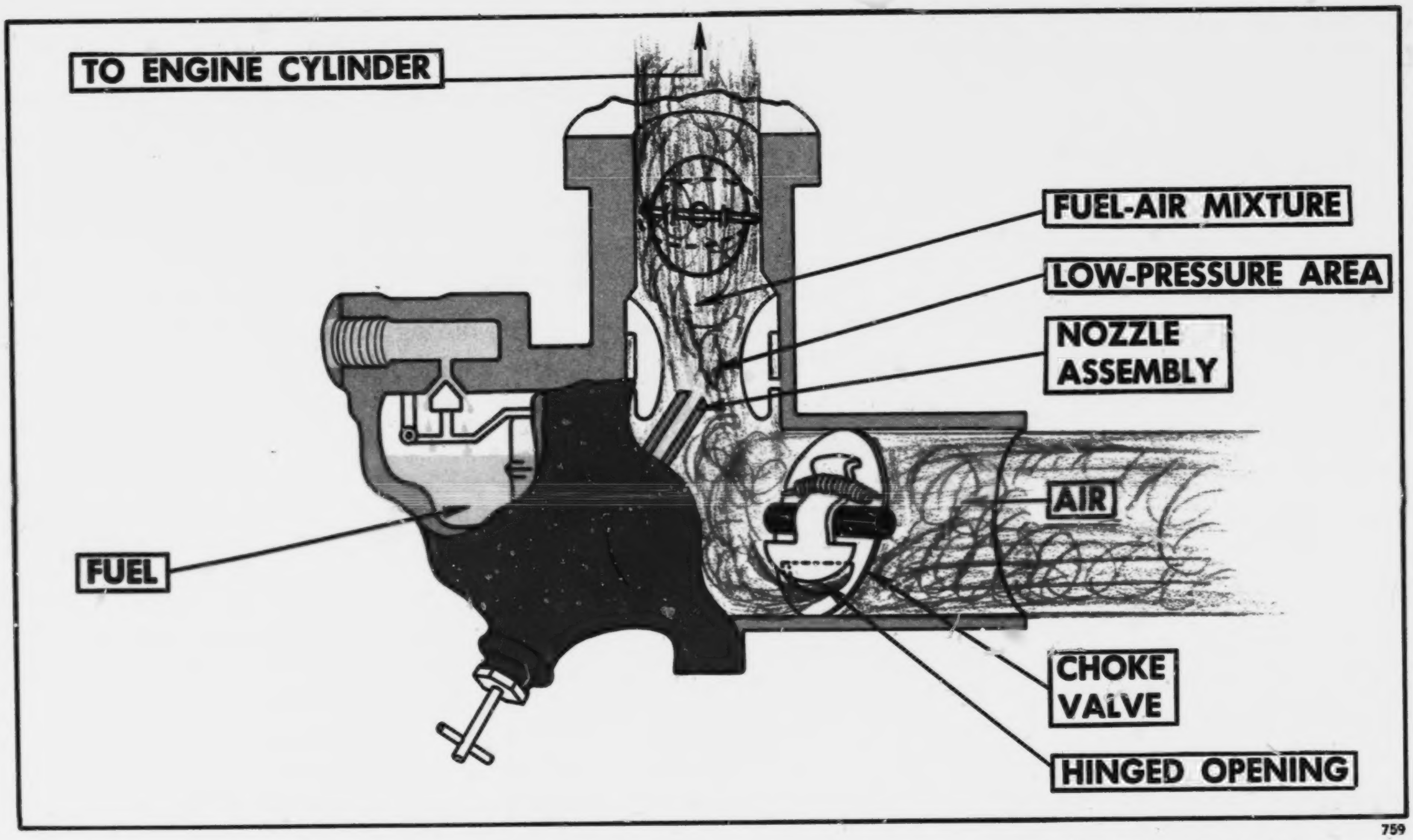

TO ENGINE CYLINDER
FUEL-AIR MIXTURE
LOW-PRESSURE AREA
NOZZLE ASSEMBLY
AIR
FUEL
CHOKE VALVE
HINGED OPENING
759

FIGURE 145. When the choke valve is closed, it limits the amount of air that can enter the carburetor. Pressure is further reduced in the induction system. The low pressure serves two purposes: (1) more fuel is forced into the induction system and (2) more fuel is vaporized.

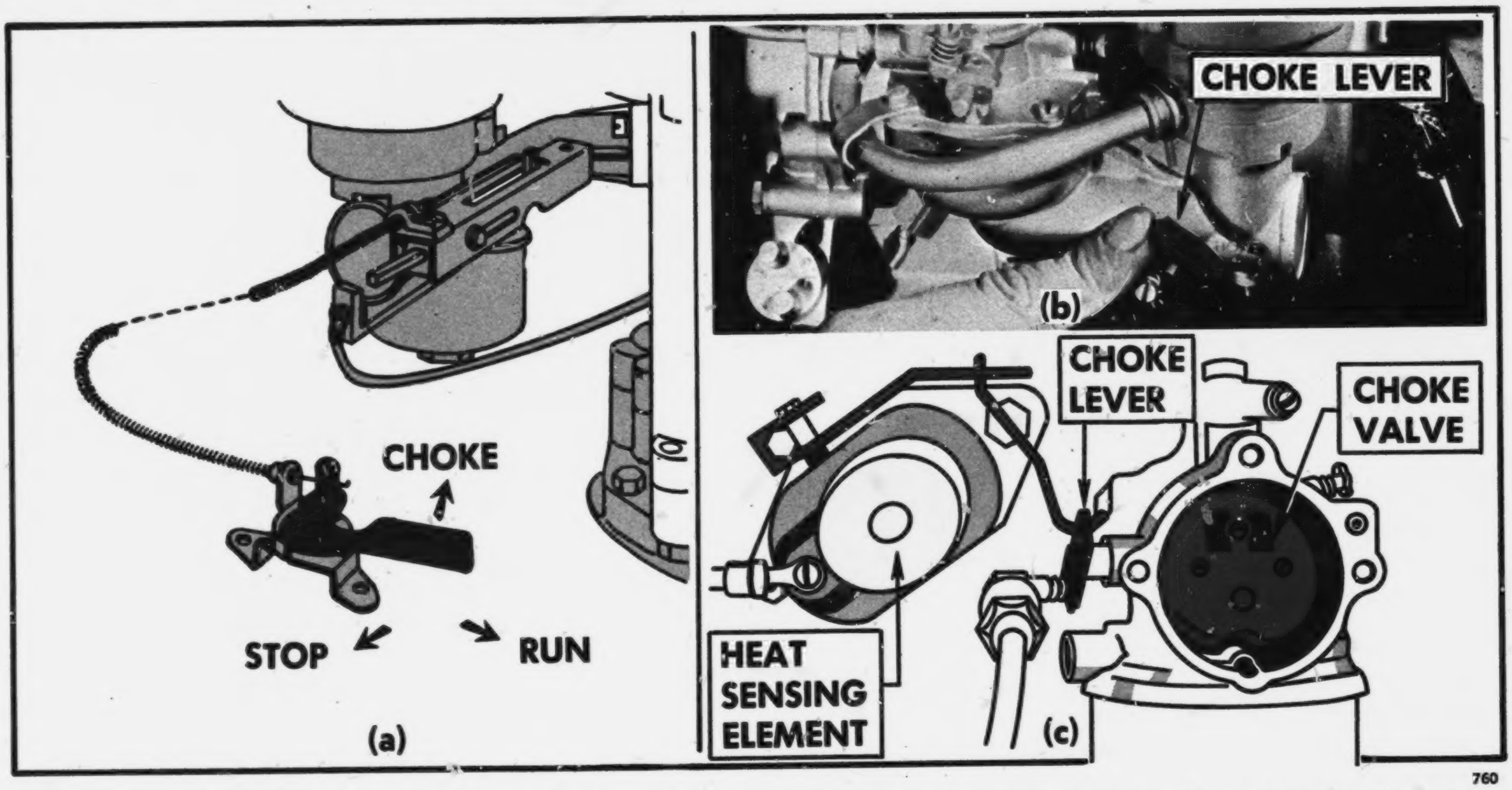

CHOKE
STOP
RUN
(a)
CHOKE LEVER
(b)
CHOKE LEVER
CHOKE VALVE
HEAT SENSING ELEMENT
(c)
760

FIGURE 146. Types of choke controls. (a) Push or pull levers at the operator's position. This is often the throttle control also. The choke is closed when the throttle is completely open. (b) A lever on the carburetor. (c) Automatic type. When engine is cold, the choke closes automatically and opens as the engine warms.

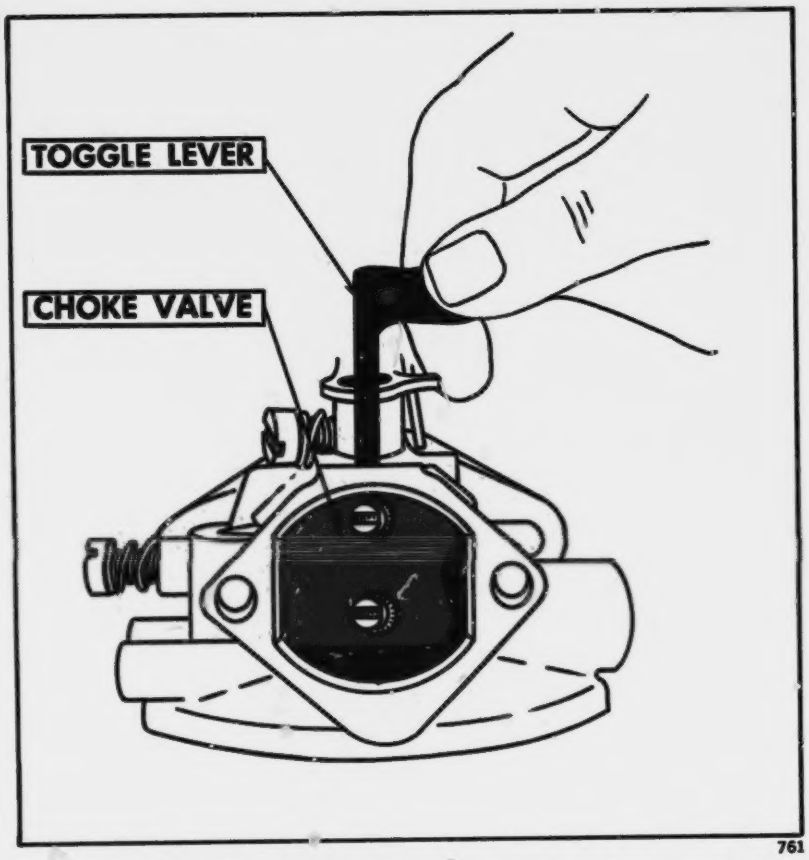


FIGURE 147. Checking the choke valve for operation. Valve is in a closed position.

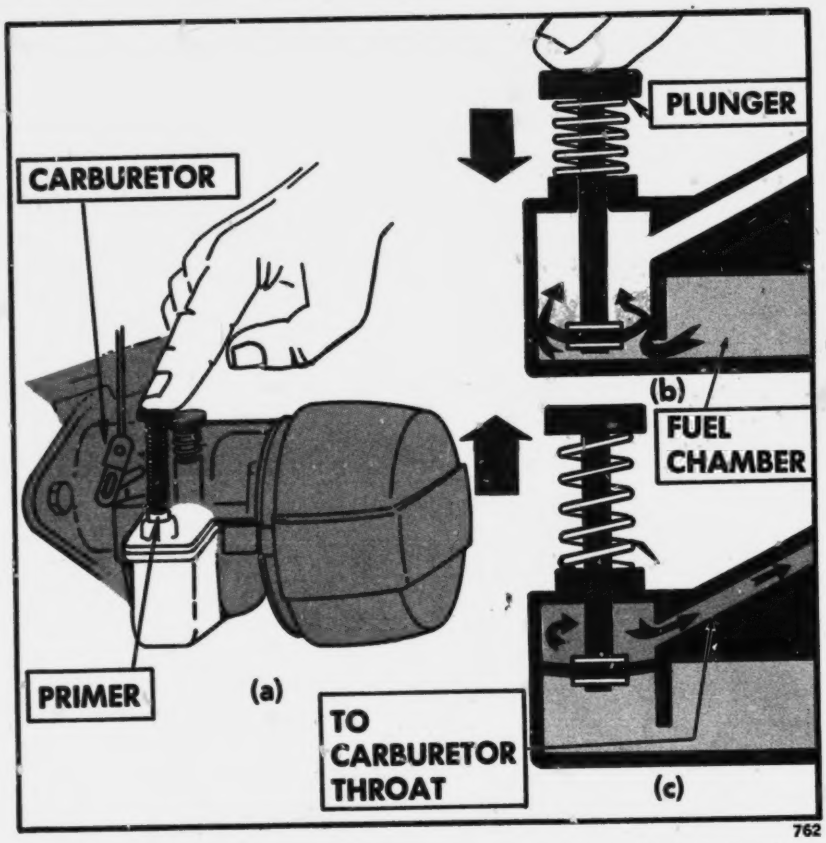


FIGURE 148. Primers are used to pump raw fuel into the carburetor for starting on some engines. (a) Outside view. (b) Cutaway view. When the plunger is pressed down, fuel is forced by the cup-shaped disk. When the plunger is released, spring tension lifts the disk and the fuel. Repeated strokes pump fuel into the carburetor throat.

If your engine has a **fuel pump and a choke, but no primer,** crank it a few turns with the ignition switch off. This action allows the fuel pump to fill the fuel lines and to supply extra fuel to the carburetor.

Some engines require little or no choking and priming during warm weather. Neither does a warm engine usually require choking or priming.

If your engine has a **suction type carburetor,** crank it 3 or 4 turns with the switch off and the choke on before attempting to start it.

CAUTION! Operate the controls from the operator's position if possible. For example, you should be seated in the tractor seat before starting your small tractor (Figure 150). You are in position to stop the engine if necessary and to control the equipment.

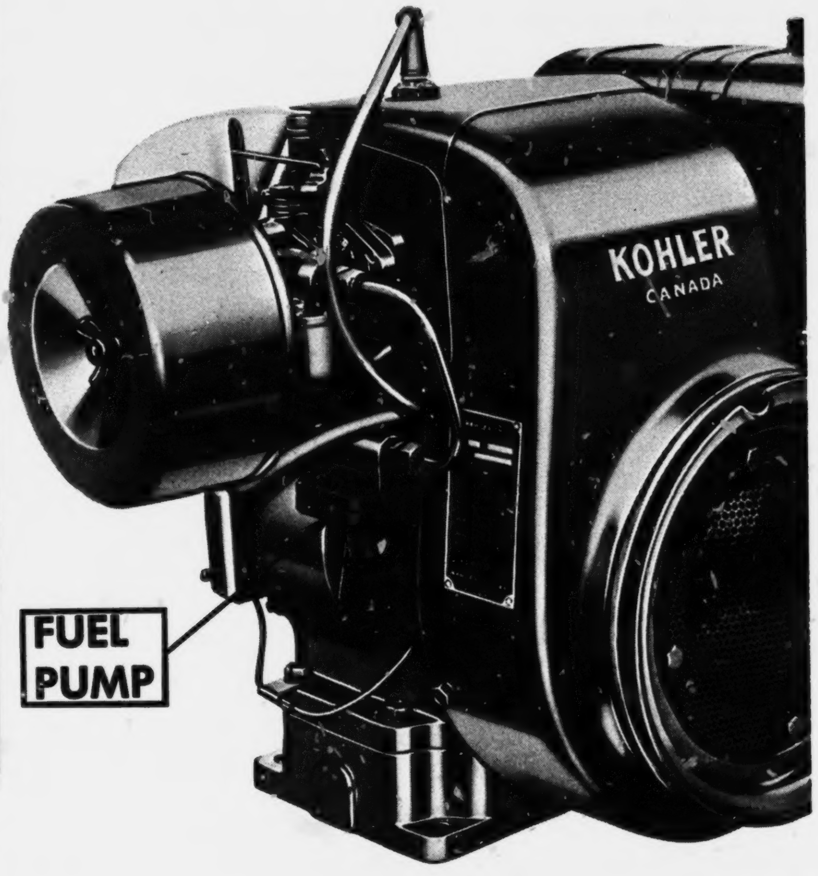


FIGURE 149. An engine with a fuel pump and choke, but no primer, requires a few turns of the starter with the ignition switch off.

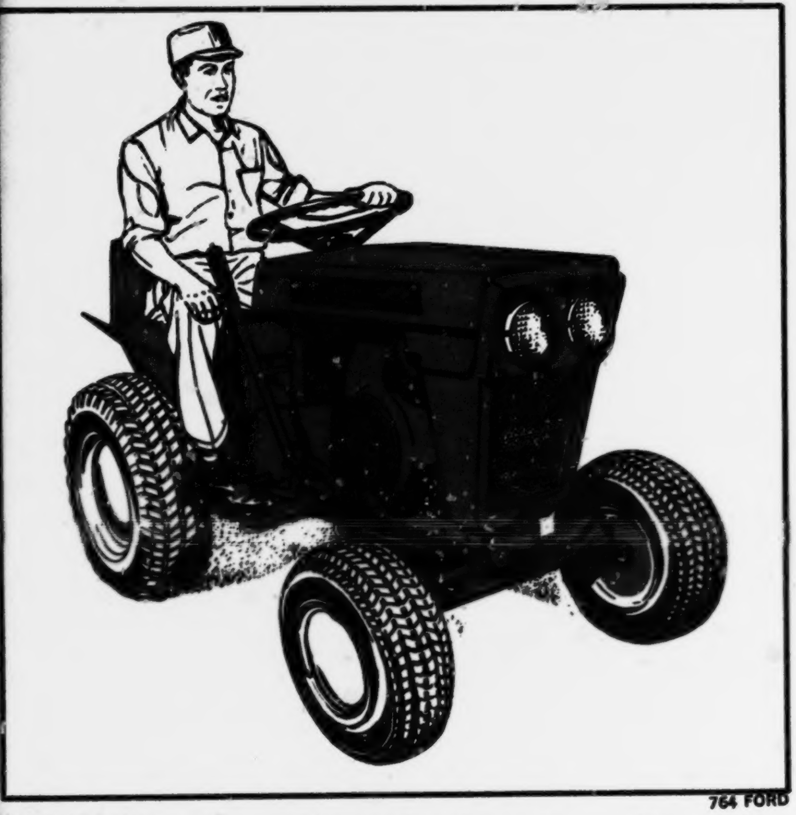


FIGURE 150. Operate the engine from the position of the equipment operator whenever possible.

3. *Set throttle at position recommended for your engine (Figure 151).*

Usually 1/4 to 1/2 open is sufficient.

If your **choke and throttle lever are combined,** move lever to choke position for starting. Then when engine starts, move it to the run position.

This operation is not necessary on engines with automatic chokes. The valve opens automatically when the engine starts.

If your **engine has no throttle control lever,** the throttle is adjusted at the carburetor for normal operations. There is no manual control. Do not adjust this type throttle for starting.

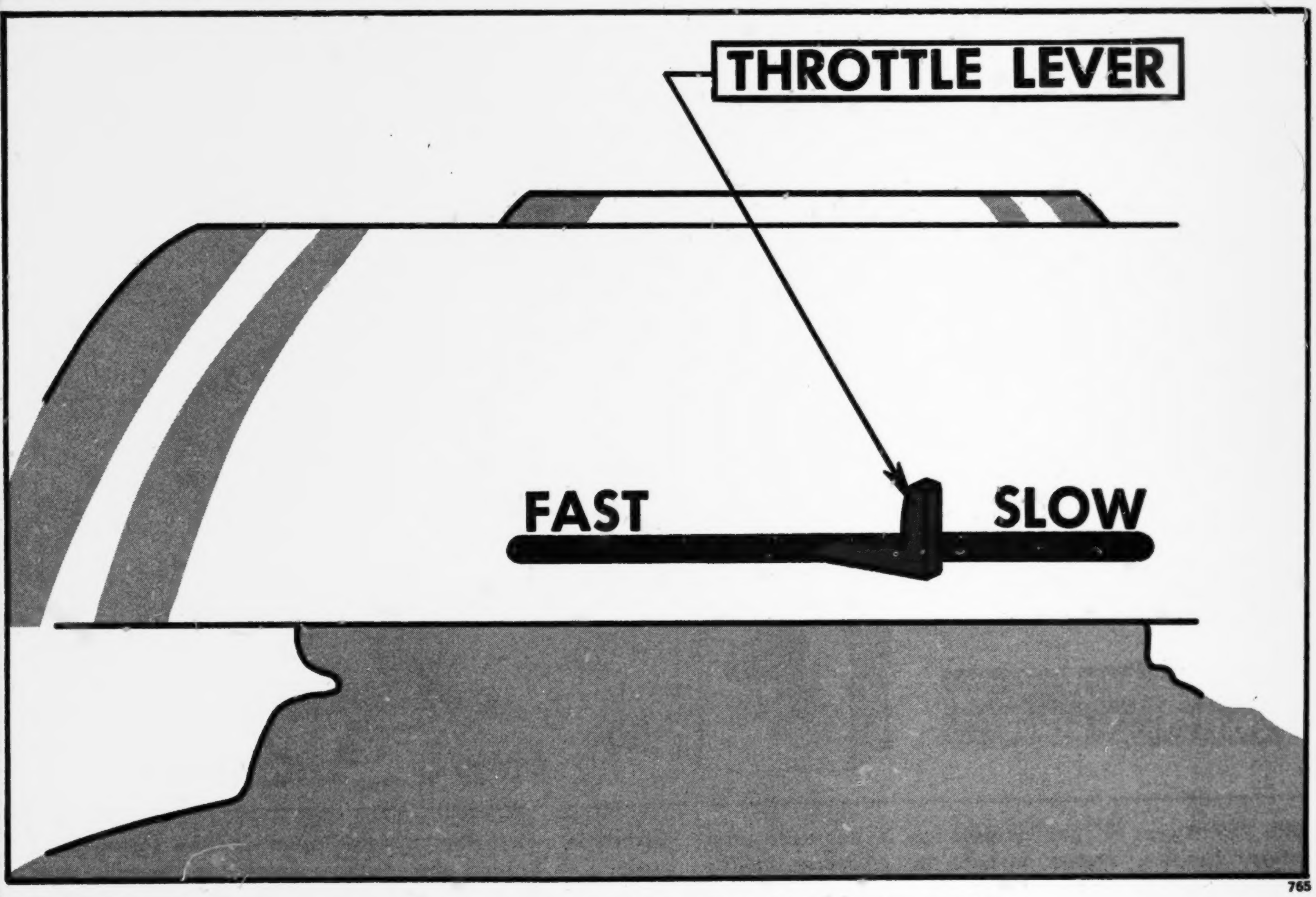


FIGURE 151. The throttle lever on most engines should be 1/4 to 1/2 open for starting.

4. *Turn on the ignition switch (Figure 152) if engine has one.*

Ignition switches are usually marked for "on" or "off."

Engines equipped with **magneto ignitions** have some type of grounding switch. As shown in Figure 152c and d, the switch is "on" when the grounding switch is "open"—not grounded. To stop the engine the grounding switch is closed. This provides another path — short circuits — for the spark plug current. The engine stops.

On some engines this switch is part of the throttle control. When the throttle is opened, the grounding switch is open (Figure 152e).

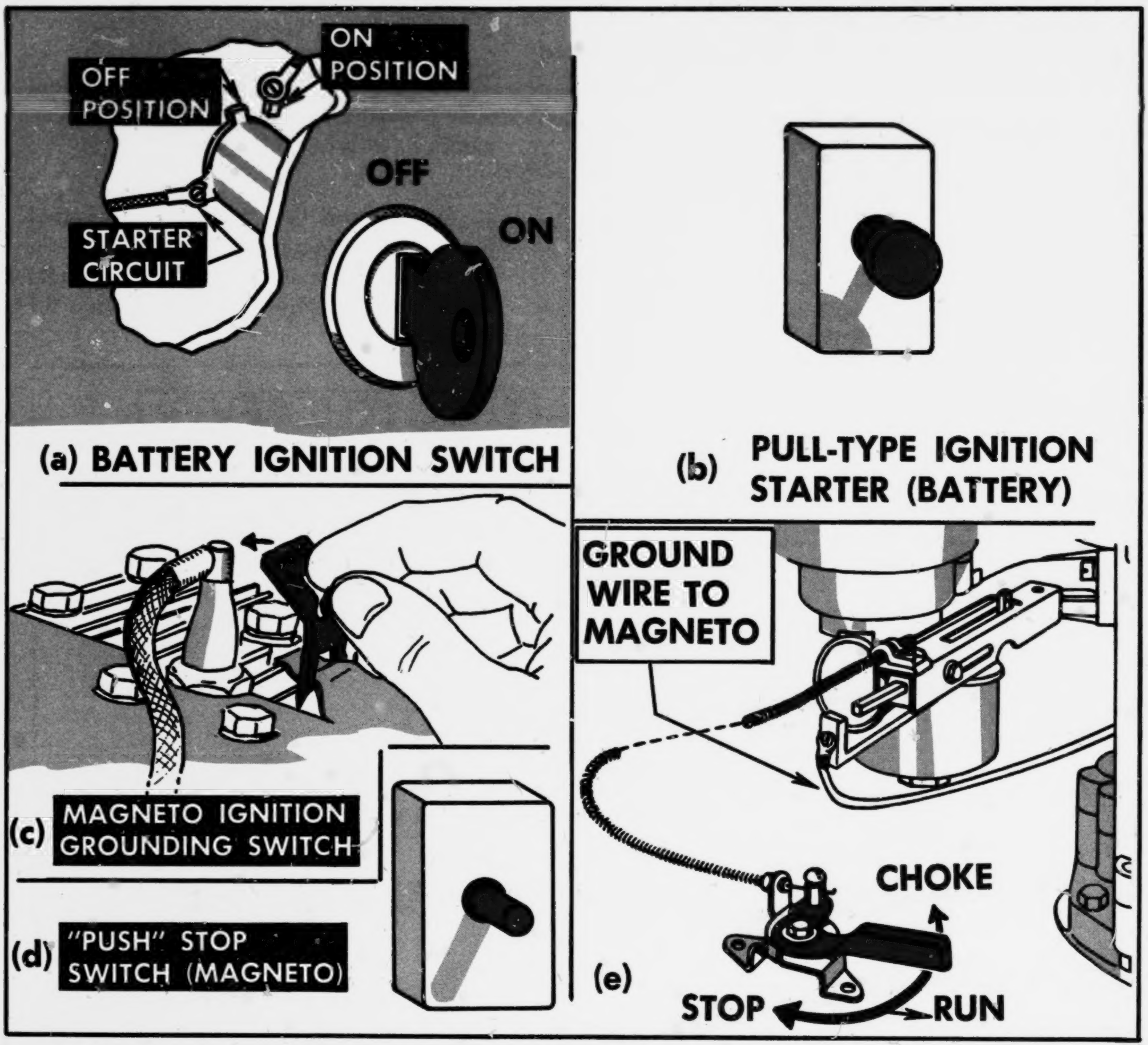

ON POSITION
OFF POSITION
OFF
ON
STARTER CIRCUIT
(a) BATTERY IGNITION SWITCH
(b) PULL-TYPE IGNITION STARTER (BATTERY)
(c) MAGNETO IGNITION GROUNDING SWITCH
(d) "PUSH" STOP SWITCH (MAGNETO)
GROUND WIRE TO MAGNETO
CHOKE
(e)
STOP
RUN
766

FIGURE 152. Types of ignition switches. Types used with a battery ignition system include (a) a rotary switch operated by an ignition key and (b) a pull-type switch that is "on" when pulled out. Types used with a magneto ignition system include (c) a grounding switch that must be "open" for the engine to run, (d) a spring-loaded push-type switch that is held "open" by the spring until pressed to ground the ignition circuit for stopping and (e) a remote-control type that works with the throttle lever. When the control lever is advanced to RUN, the slide bar moves ahead, thus automatically opening the connection to the ground wire.

How this type of ignition system works is explained more completely under "Maintaining and Repairing Magneto Ignition Systems," Volume II.

5. *Crank the engine.*

   There are several different types of starters used on small engines. The procedures you use for cranking will depend upon the type starter you have. Four common types are discussed as follows: (a) **rope-wind** (Figure 153, (b) **rope-rewind** (Figure 155), (c) **wind-up** (Figure 156) and (d) **electric** Figure 157).

   a. If your engine has a **rope-wind starter (Figure 153),** proceed as follows:

      (1) *Wind rope around flywheel pulley.*

      (2) *Crank engine slowly until it reaches the compression stroke (Figure 153).*

      (3) *Rewind rope until you have a short section left.*

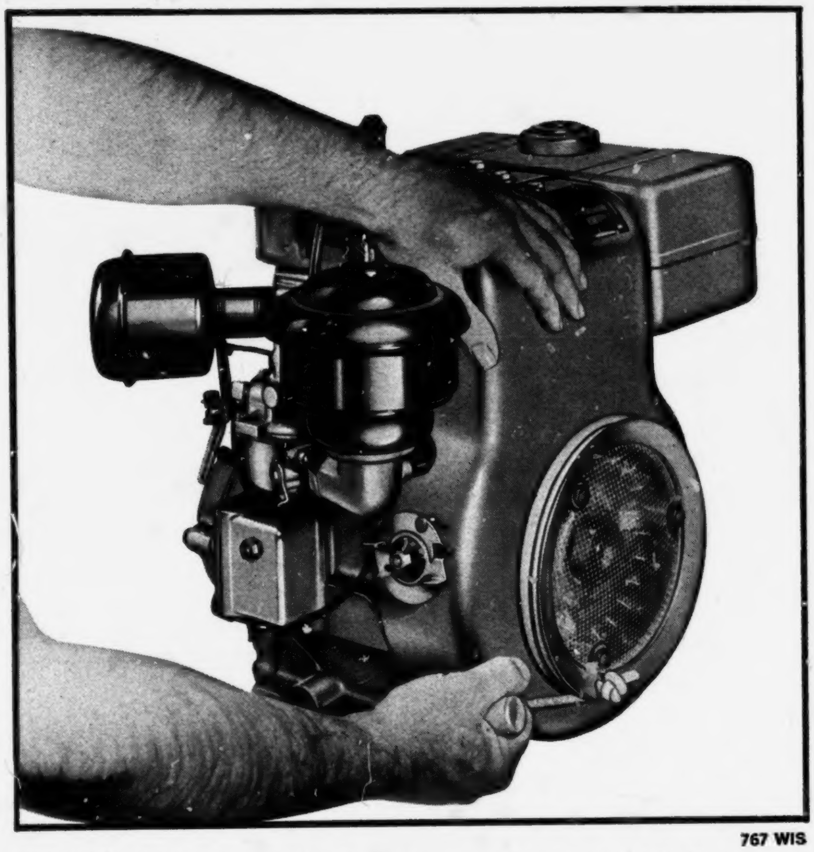


FIGURE 153. A rope-wind starter. One end of the rope is held by a notch in the starter pulley. It is wound onto the pulley and then pulled. This cranks the engine.

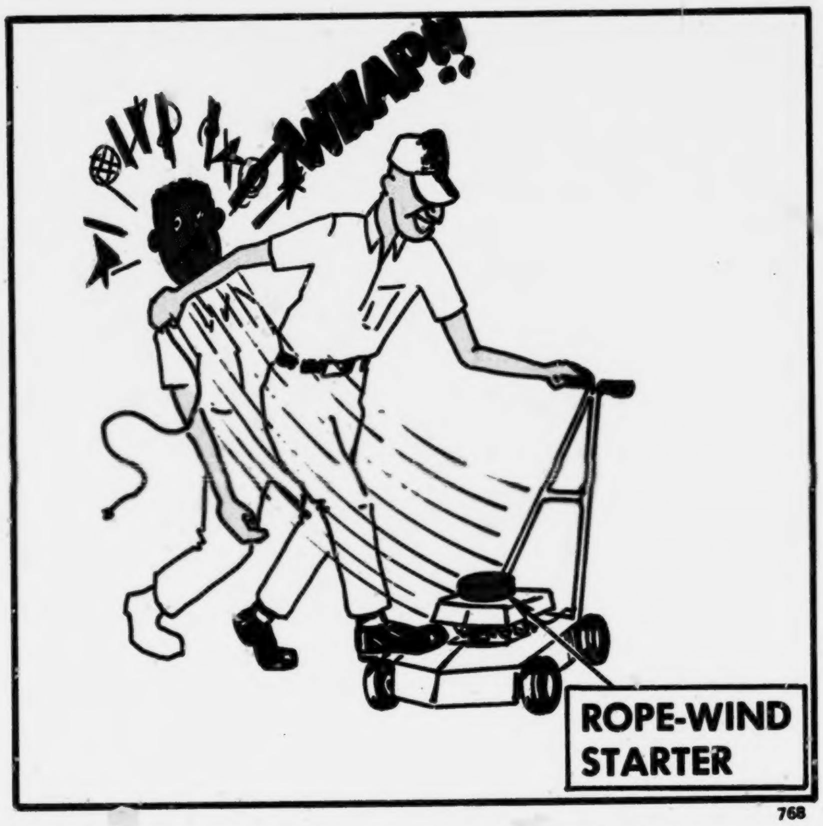


FIGURE 154. Watch the other fellow and give yourself plenty of room when pulling a crank rope.

      (4) *Pull rope all the way.*

      Brace yourself against the engine.

      Pull rope straight and evenly.

CAUTION! When cranking an engine, brace your hand against it to avoid pulling the engine onto you (Figure 153). This can be very dangerous in case of lawn mowers and chain saws.

Be sure no one is immediately behind you when starting with a rope-wind starter (Figure 154).

Keep children and pets a safe distance away from the engine.

   b. If your engine is equipped with a **rope-rewind starter (Figure 155),** proceed as follows:

      (1) *Pull rope to crank engine slowly until it comes to compression stroke.*

      If you are starting a chain saw, place it on the ground and hold it with one

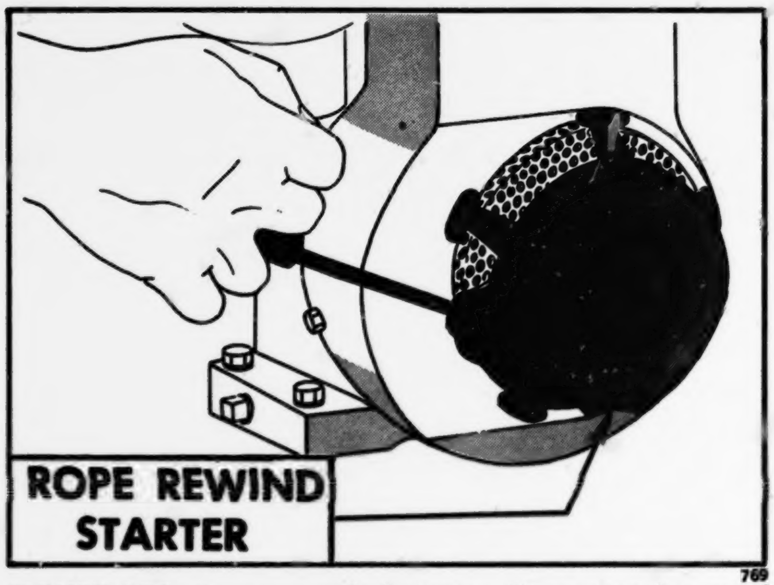


FIGURE 155. A rope-rewind starter. Rope remains on the starter in a wound position. After the starter is operated, the rope is automatically rewound by a spring on the starter pulley.

hand while pulling the rope with the other.

CAUTION! Never try to crank a chain saw engine while suspending the saw in the air. There is a danger of the saw getting out of control and the chain striking your leg.

(2) *Slacken rope and allow it to rewind.*

(3) *Pull rope briskly and firmly — but not all the way.*

The end of the rope is anchored to the starter pulley, and there is a danger of breaking the rope.

(4) *Hold to the rope handle and allow the rope to rewind.*

This action prevents damage to the starter spring and avoids binding of the rope.

c. If your engine is equipped with a **wind-up starter (Figure 156),** proceed as follows:

(1) *Place release lever in wind-up position.*

This holds the spring.

(2) *Lift handle and extend to cranking position.*

(3) *Wind starter (Figure 156).*

Turn handle in direction indicated on your engine.

(4) *Fold wind-up handle to retracted position.*

(5) *Move release lever to "run" position.*

CAUTION! Never work on engine or equipment when a wind-up starter is wound. If equipment becomes jammed so that starter will not crank engine, place release lever in "wind-up" position. What to do is explained under "Repairing Wind-up Starters," Volume II.

The spring is released and cranks the engine.

NOTE: Leave release lever in "run" position while you are operating the engine to prevent damage to starter (Figure 156).

d. If your engine is equipped with an **electric starter,** proceed as follows (Figures 157 and 158):

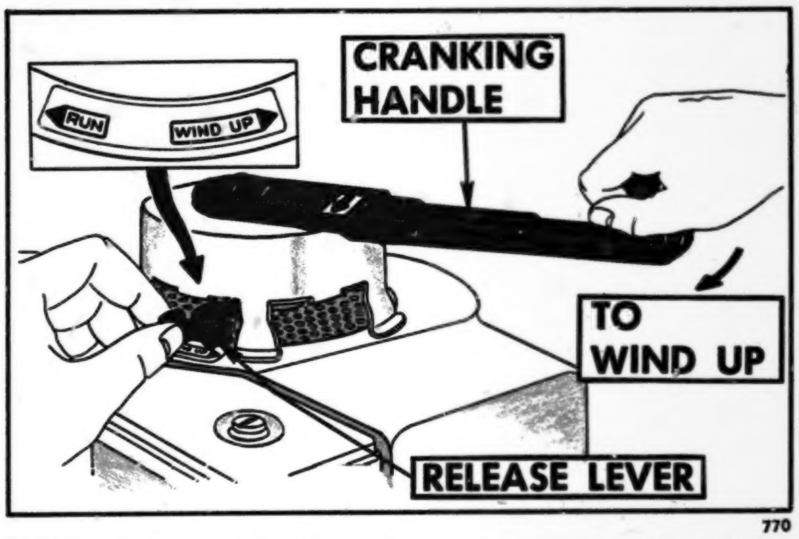


FIGURE 156. A wind-up starter. Starter is activated by a strong coil spring on the starter pulley. It is wound by a handle and then released. Engine is cranked by the impulse.

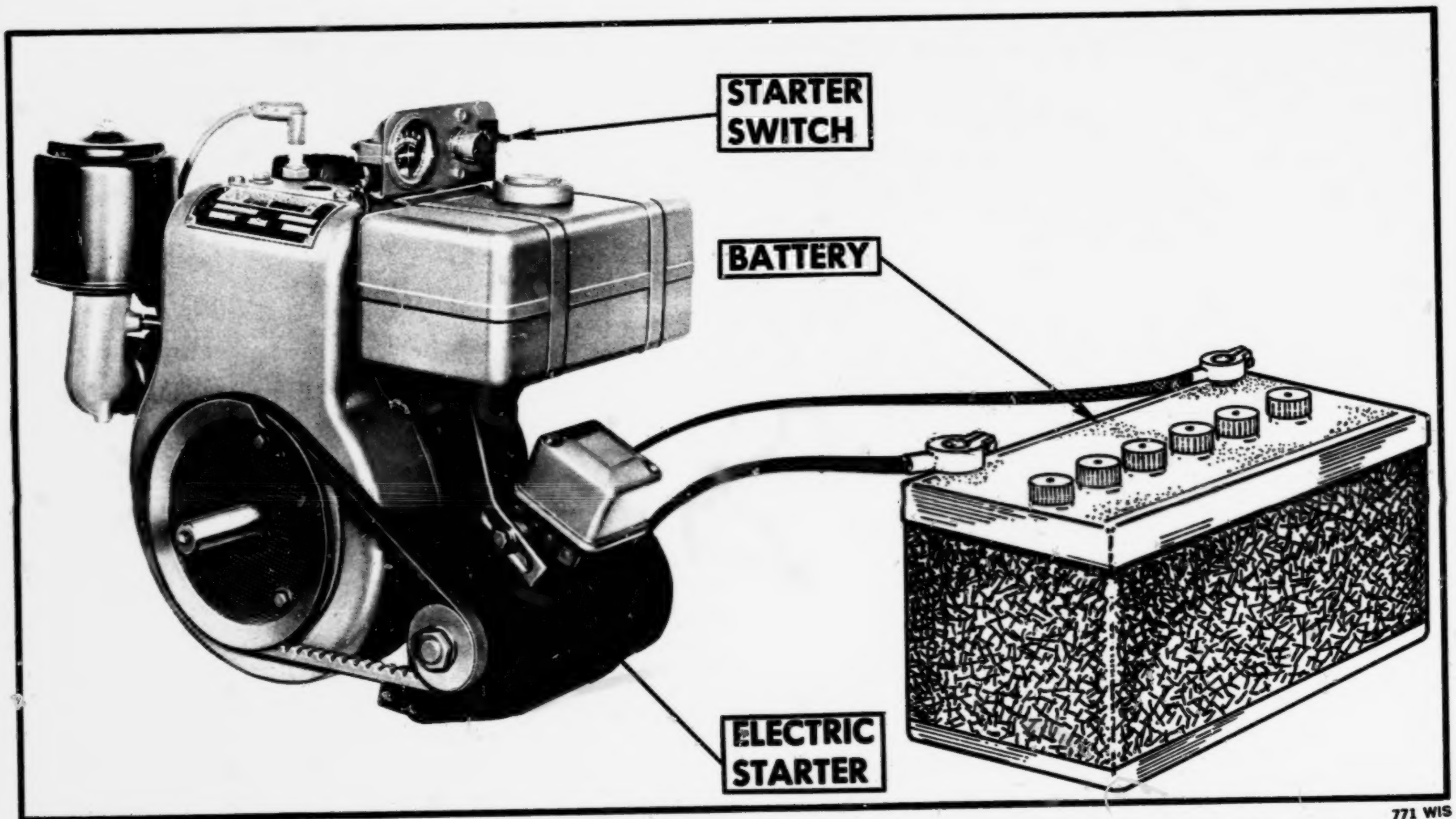

STARTER SWITCH
BATTERY
ELECTRIC STARTER
771 WIS

FIGURE 157. An electric starter-generator combination. This type starter is operated by a switch. It receives electric power from a storage battery.

(1) *Engage the starter switch for not more than 10 seconds and release.*

Electric starters may be operated by means of the ignition key, by a push button or by a pull knob.

The starter switch automatically returns to the "off" position when released. This prevents the starter from overheating.

6. *Open the choke valve part or all the way when the engine starts.*

Some choke valves snap completely open. Others are designed for partial opening until the engine warms up.

7. *Adjust the throttle for warm-up.*

Set for fast idle.

Never open the throttle completely, gun the engine or apply load until the engine has

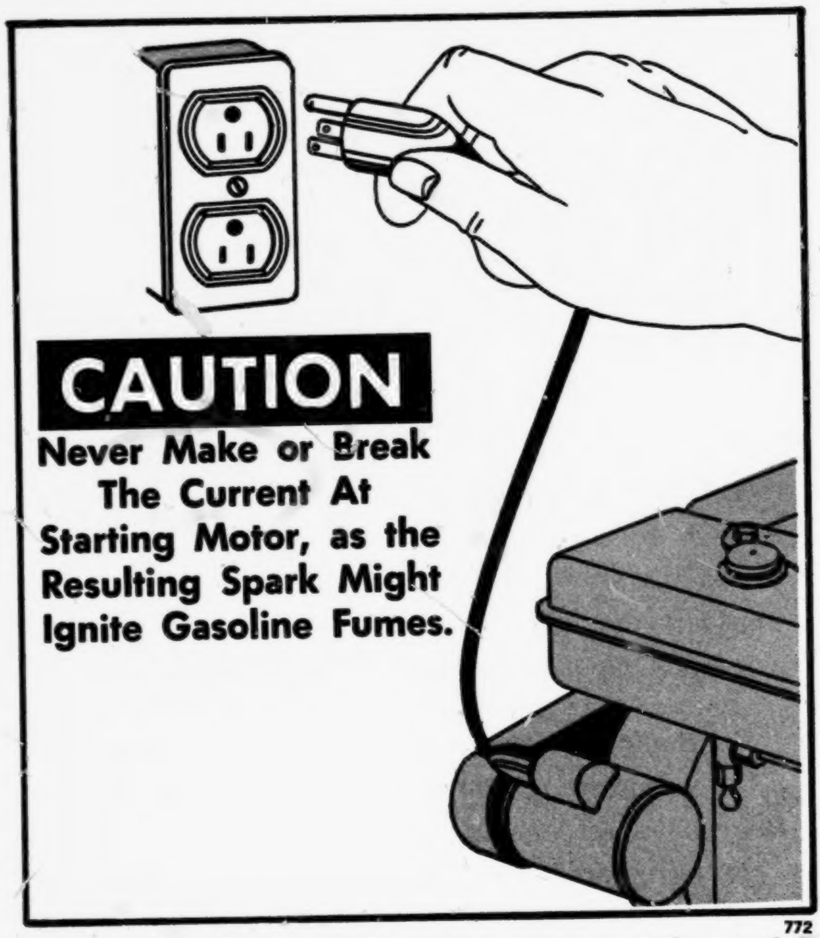

CAUTION
Never Make or Break The Current At Starting Motor, as the Resulting Spark Might Ignite Gasoline Fumes.
772

FIGURE 158. Plug in an A.C. electric starter at the service outlet after connecting it to the starter motor to avoid the possibility of sparks occurring near the engine and starting a fire.

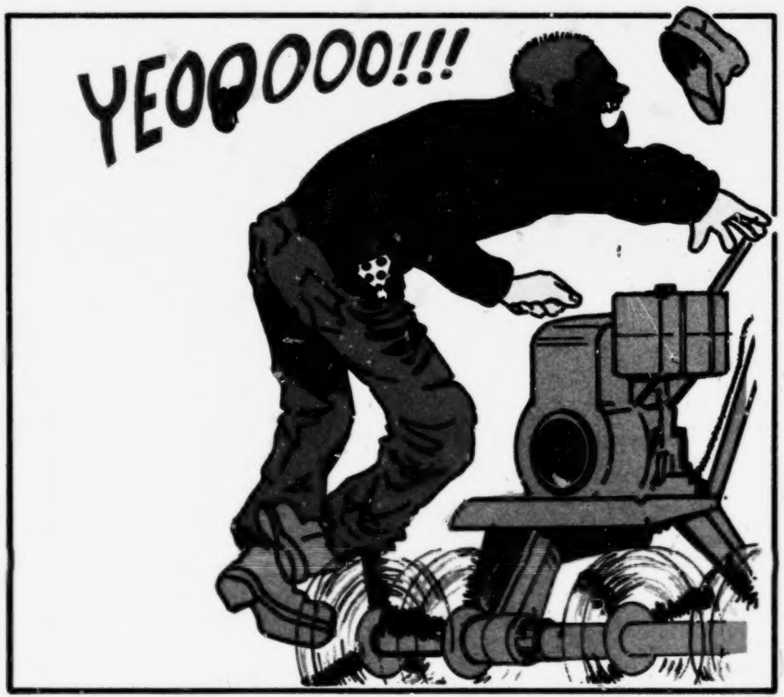


FIGURE 159. Moving parts are dangerous.

warmed up. Operate for at least one minute. This allows time for oil to get to the bearing surfaces.

CAUTION! To prevent injury stay clear of moving parts any time the engine is running (Figure 159).

8. *Repeat steps 1 through 4 if the engine does not start.*

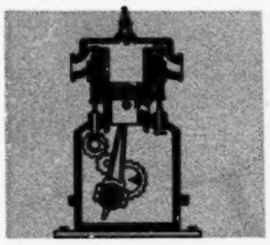
If the engine *does not start* after *two or three* attempts, recheck your procedures and try again. Then if the engine does not start, follow the procedures given under the headings:

"Servicing Spark plugs," page 74.

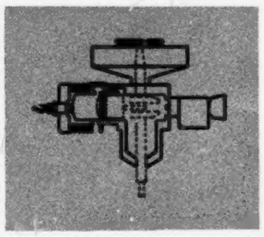
"Checking and Adjusting Carburetors," page 86.

"Checking Compression," page 110.

"Checking and Servicing Batteries," page 111, if your engine has a direct current electric starter.



B. OPERATING ENGINES



Are you guilty of *gunning your engine?* There seems to be a certain amount of pleasure derived from racing an engine — for no apparent reason. All manufacturers warn against it — especially during warm-up. One manufacturer puts it this way:

> *Racing an engine* or *gunning it,* to hurry the warm-up period, is very destructive to the polished wearing surfaces on pistons, rings, cylinders, bearings, etc., as the proper oil film on these various surfaces cannot be established until the oil has warmed up and becomes sufficiently fluid. This is especially important on new engines, and in cool weather.[6]

Small engines are tough (Figure 160a). They will stand much punishment. Abuse during operation, however, shortens their service life (Figure 160b).

What you need to know when operating your engine is discussed under the following headings:

1. Importance of proper operation.
2. Adjusting the engine speed and load.
3. Stopping the engine.

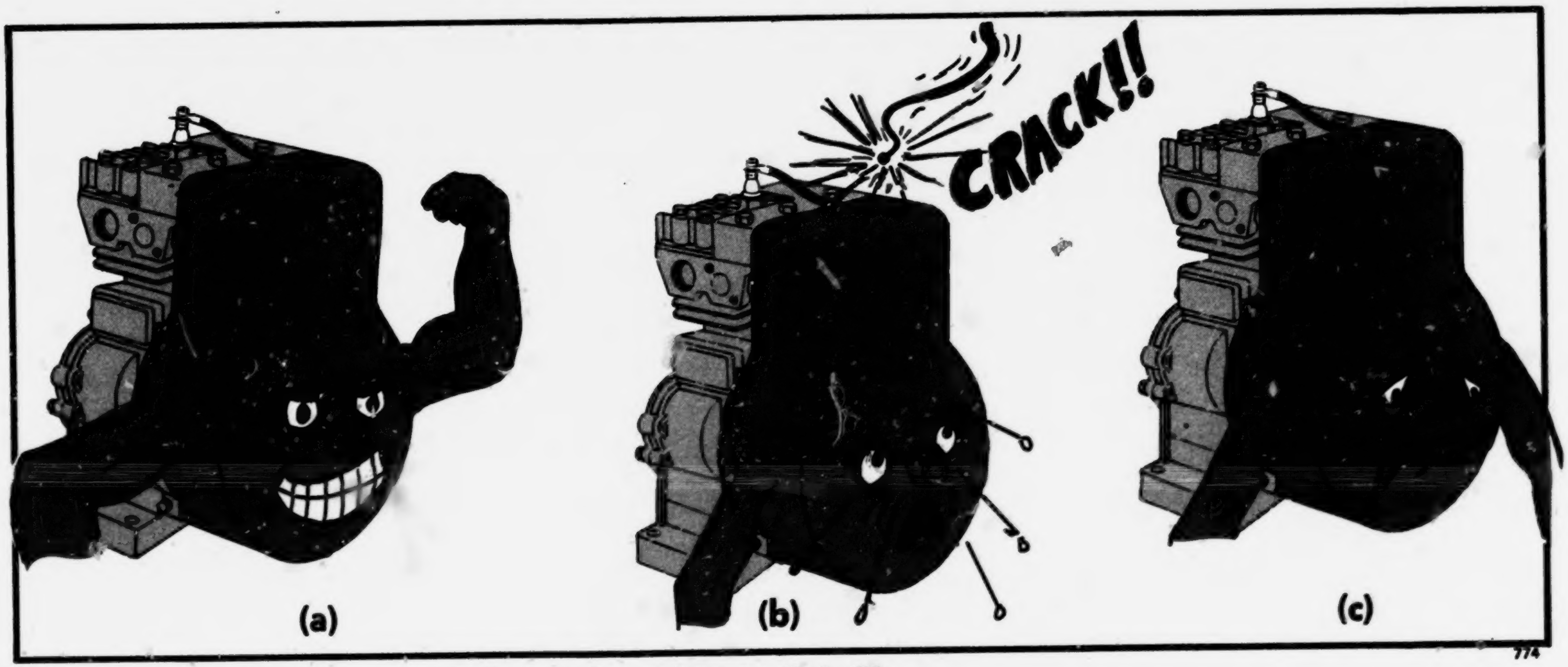


FIGURE 160. Small engines are tough, but abuse shortens their life.

IMPORTANCE OF PROPER OPERATION

There are many ways by which small engines are abused, but most of them suffer either from **overspeeding** and/or from **overloading** more than from anything else.

Overspeeding an engine beyond its designed operating speed shortens its life. It can also be dangerous. You can actually cause the engine to "blow up" by operating it at excessive speeds.

Excessive speeds may also affect the life and safety limits of the equipment on which the engine is mounted. According to the American Standards Association, *21,000 feet per minute* is the *maximum*

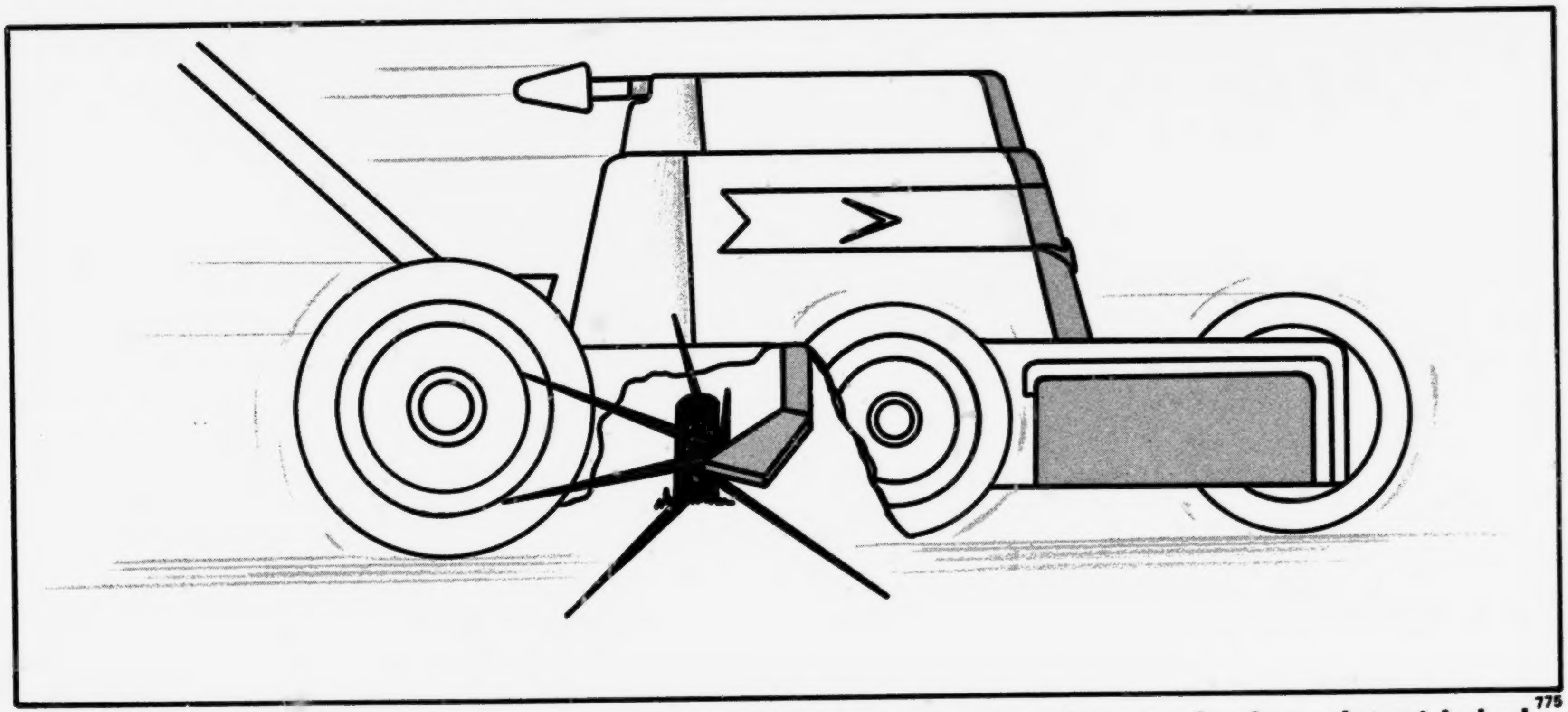


FIGURE 161. An engine operating under normal conditions may sometimes have to absorb a substantial shock.

safe speed at which the tip of a lawn mower blade should travel. Lawn-mower manufacturers comply with this standard in their design. But if you change the governor to increase the speed of your engine beyond that which is recommended, you may exceed the safety speed at which the blade turns.

For example, if your mower has a 24-inch blade (direct drive), the engine speed should not exceed 3340 r.p.m. If you increase it to 3600 r.p.m., the blade tip speed will be 22,620 feet per minute — which is over the safe limit. If you increased your engine speed to 4,000 r.p.m., the blade tip speed would be approximately 25,000 feet per minute, or approximately 300 miles per hour.

A lawn-mower blade is dangerous enough at normal speeds. A test conducted on a rotary lawn mower by one manufacturer revealed some indication of the force generated by small engines (Figure 161). With the engine turning at 3600 r.p.m. and driving an 18" x 2" blade, the blade was stopped suddenly and the force of impact was measured. **Thirty-four tons** of impact force were exerted against the stop.[7]

Overloading is also a common abuse of small gasoline engines. Overloading causes overheating and extra loads on the bearings. Overheating contributes to excessive varnish and carbon accumulation inside the engine from breaking down the chemical composition of the oil. This accumulation causes piston rings and valves to stick. Low compression and loss of power result. Generally, you will not realize anything is wrong until the valves are burned and/or the rings are broken. Then repairs become expensive.

ADJUSTING THE ENGINE SPEED AND LOAD

Manufacturers recommend a few simple suggestions for operating small engines. At first they may seem unimportant to you, but you will be surprised at the improved service you get from your engine if you follow the operating instructions (Figure 162).

FIGURE 162. Following a few simple procedures will reward you with many safe hours of trouble-free operation.

1. *Read the operating instructions for both the equipment and the engine, unless you are already familiar with them.*

2. *Allow your engine to warm up after starting and before bringing it up to speed or applying a load.*

   Operate at high idle speed (approximately 1/3 throttle). Too low an idle speed will cause the spark plug to become fouled with unburned fuel.

   CAUTION! Never operate an engine in a closed building. There is a danger of your being overcome by carbon monoxide gas.

3. *Adjust throttle position.*

   Most small engines are designed for continuous operation under load at full throttle. Manufacturers say that it is better to operate the engine at the continuous operating speed for which it is designed than to risk overloading the engine while it is being operated at a lower speed. This is assuming that the governor adjustment has not been changed. The governor is set so that it will hold the engine speed to a continuous operating speed. How this works is explained under "Types of Governors and How They Work," Volume II.

If your engine is **new or rebuilt and if it is a 2-cycle type,** adjust the carburetor for a fairly rich mixture for the first 10 hours. This is for better lubrication of the new parts. There is no break in period recommended for 2-cycle engines.

If your engine is **new or rebuilt and is a 4-cycle type,** adjust the throttle to approximately 1000 to 1200 r.p.m. (about 1/3 throttle) and operate it for 1/2 hour without load. Then increase the engine speed to maximum governed speed without load for 1/2 hour. Operate rebuilt engines an additional 3 1/2 to 4 hours before applying full load.

4. *Apply load to the engine.*

   Apply load gradually. Do not overload.

   If your engine is a **new one or is rebuilt,** operate it at full throttle for at least 10 hours under light load to assure adequate lubrication during the break-in period, unless the manufacturer recommends a different procedure.

5. *Follow the proper operational procedures.*

   CAUTION! Do not leave your engine running while unattended. There is a danger of the equipment getting out of control and causing personal injury or property damage.

   Engines with float-type and suction carburetors may not operate satisfactorily on slopes of more than 15° (Figure 163).

   A fuel valve in float-type carburetors may be either forced open or closed when the engine is tilted. Then the engine gets either too much fuel or not enough.

   Suction type carburetors lift fuel through a suction pipe from the fuel tank or from a sump. If the engine is tilted too much, the carburetor picks up either too much fuel or not enough.

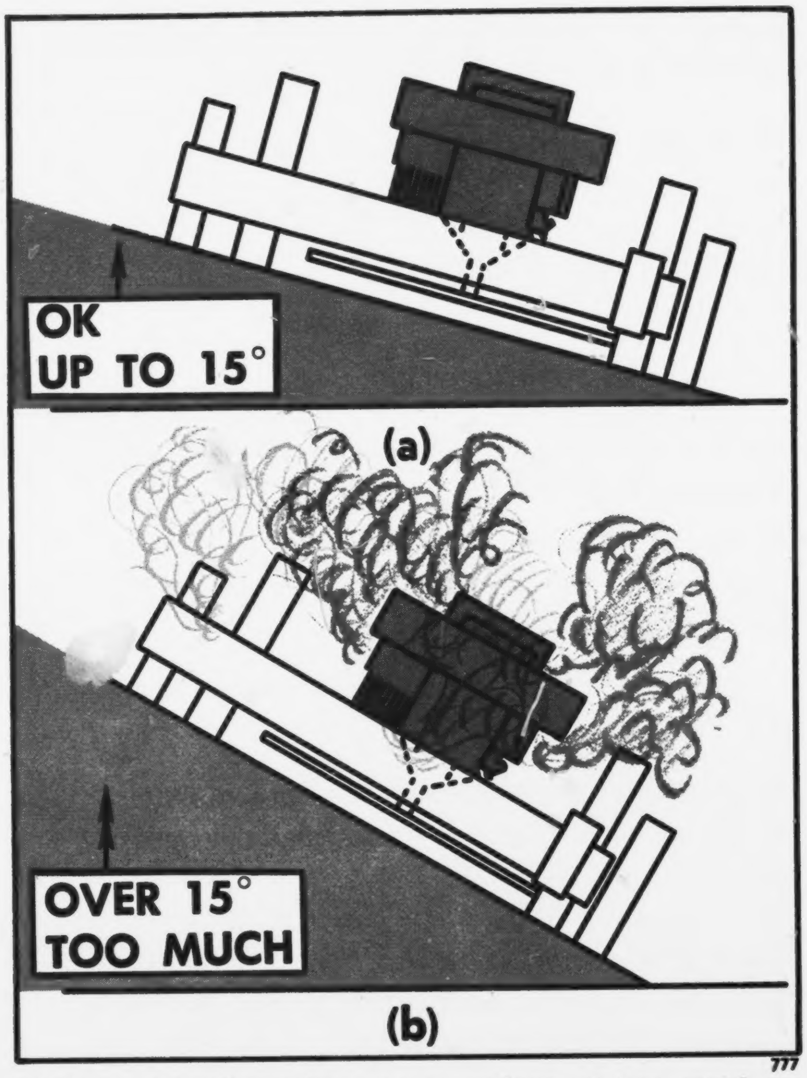


FIGURE 163. Operating some engines at too great an angle may starve the engine of fuel or oil and take oil into the carburetor from the air cleaner.

   Refer to "Types of Carburetors and How They Work," Page 90.

   If you tilt a 4-cycle engine excessively, there is a danger of starving it of oil. The oil in the oil sump may not be reached by the dipper or slinger.

   If your engine has an oil-bath type air cleaner and if the engine is tilted too much, the oil will spill into the carburetor and foul the plugs.

6. *Stop the engine if it does not run properly.*

   To locate and correct the trouble, first be sure you have performed the periodic service required for your engine. Then follow the procedures given under the headings:

"Servicing Spark plugs," page 74.

"Checking and Adjusting Carburetors," page 86.

"Checking Compression," page 110.

STOPPING THE ENGINE

1. *Remove load from the engine.*

   If you suddenly **stop an engine under load,** it suffers from "shock." Instead of coasting to a standstill, it is actually stalled. This causes shock on the bearings and increased wear.

2. *Reduce engine speed to idle.*

   Allow engine to cool for one or two minutes at ⅓ throttle speed and no load (Figure 164).

   The engine temperature may be three times higher at operating speeds than at idle speeds. Stopping the engine at a high temperature subjects it to a sudden cooling which creates stress on all the engine parts.

3. *Turn off the ignition switch.*

   On battery ignition engines, leaving the ignition switch "on" will cause the battery to discharge.

   CAUTION! If your engine is controlled by an ignition lock and key, remove it before leaving the engine. This is a safeguard against children starting the engine, operating the equipment, and getting hurt. If the engine has no ignition key, remove spark plug wire from spark plug.

4. *Close the fuel-tank shut-off valve if the engine has one.*

   This care takes the pressure off the carburetor diaphragms and/or float and prevents fuel leaks.

5. *Store the engine in a dry, protected area.*

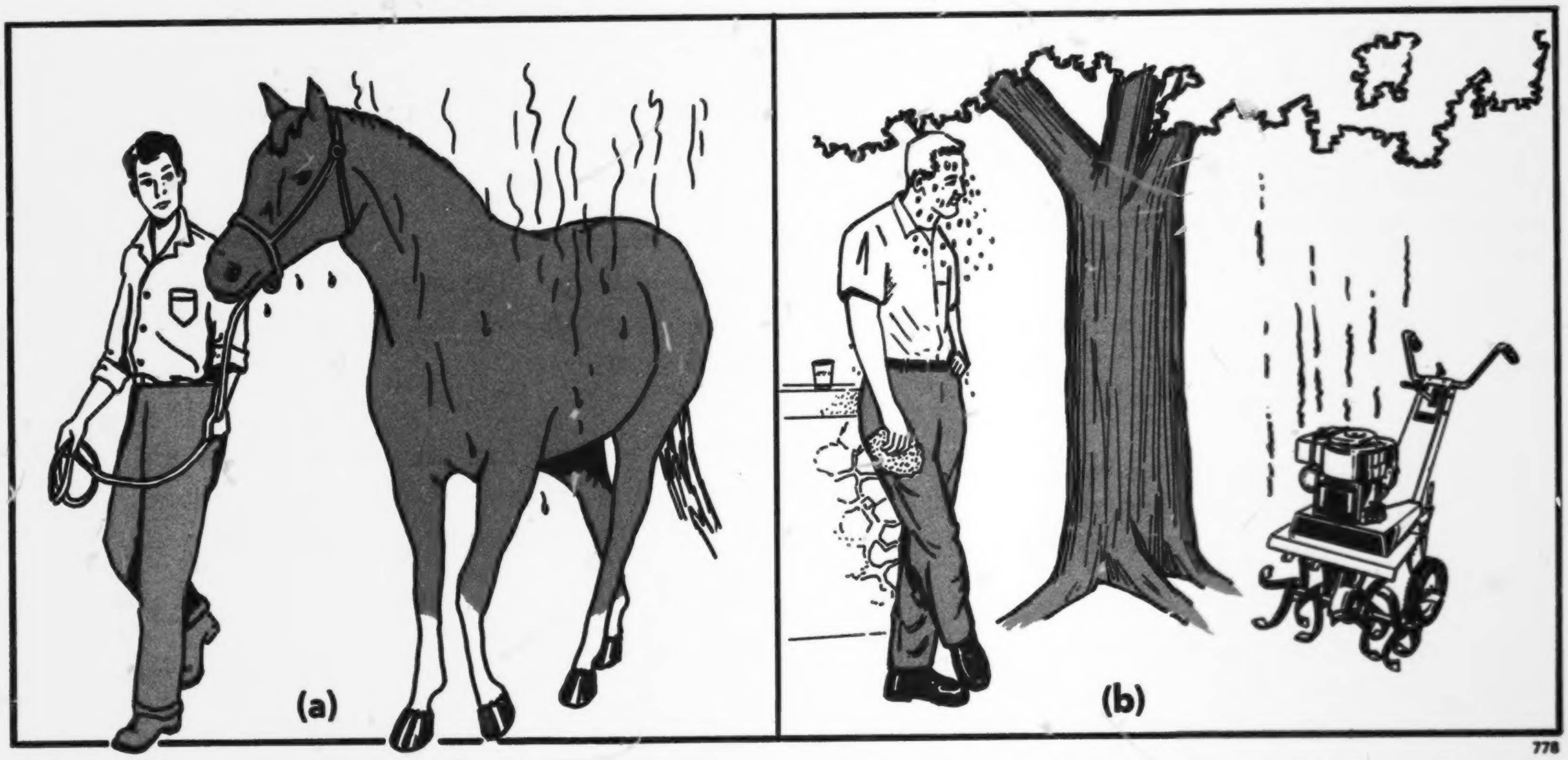
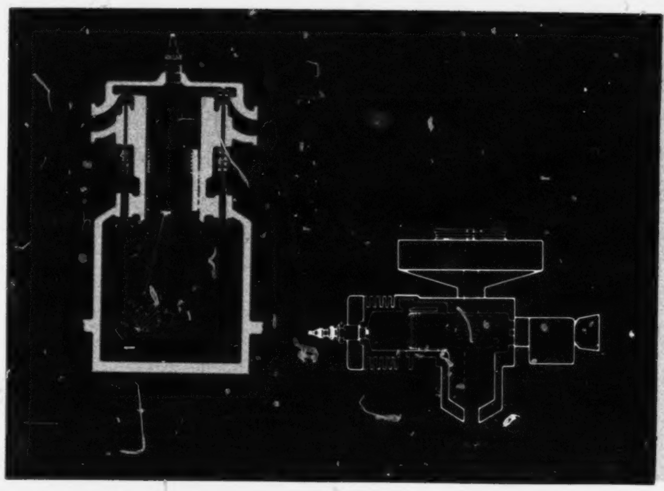


FIGURE 164. (a) Horses are walked after a race to allow them to cool down gradually. (b) For the same reason you should let your engine idle one or two minutes before stopping it.

If you do not plan to use your engine within a period of 30 days, drain the tank and carburetor. Then, just prior to using it, fill the tank with clean, fresh, regular-grade gasoline. This prevents gum from forming in the fuel system.

If you do not plan to operate your engine for three months or longer, follow procedures given under "Storing Engines," next page.



III. STORING ENGINES

Few people bother to prepare their engines for storage. But a few minutes of attention at storage time will pay off in convenience, easy starting, good performance and a longer engine life.

Why you should prepare your engine for storage and how to do it are discussed under the following headings:

1. Importance of proper storage.
2. Tools and materials needed.
3. Protecting the engine from corrosion, moisture and gum deposits.
4. Protecting the engine from dirt and physical damage.

IMPORTANCE OF PROPER STORAGE

When properly prepared for storage, engines have been known to start and run perfectly after remaining in storage for five years or longer. You probably never expect to store an engine this long; but if you do not plan to use your small engine for six months or more, you should protect it from

- **Corrosion** of any metal and iron parts such as the valves, cylinder, piston and piston rings.
- **Gum which develops from left-over fuel** in the fuel system.
- **Moisture** that collects on the outside of the engine and penetrates into electrical system and the inside of the engine.
- **Dust and dirt** which accumulate on the outside of the engine.
- **Physical damage** (Figure 165).

Corrosion during storage is not so great a problem now as it once was. Crankcase oils contain rust inhibitors which help protect the steel parts. Also, many small-engine cylinder blocks, cylinders and

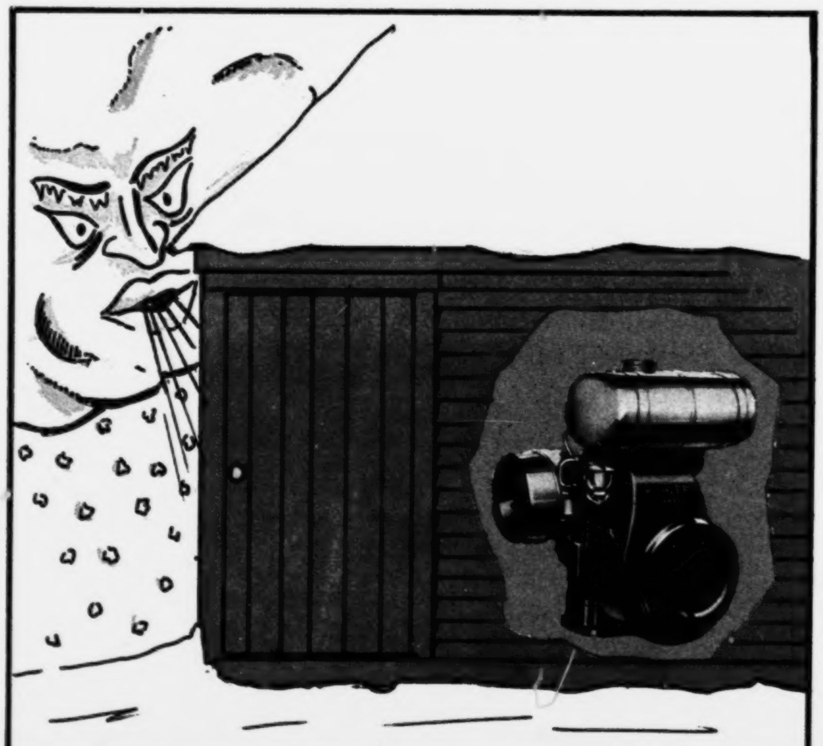
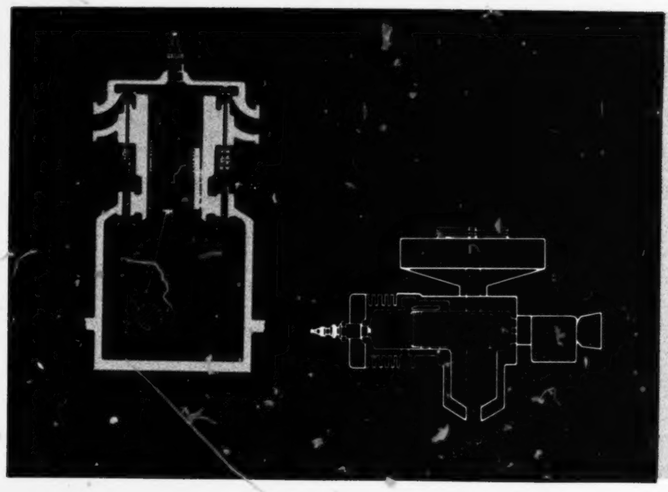


FIGURE 165. Protect your engine during storage. 779



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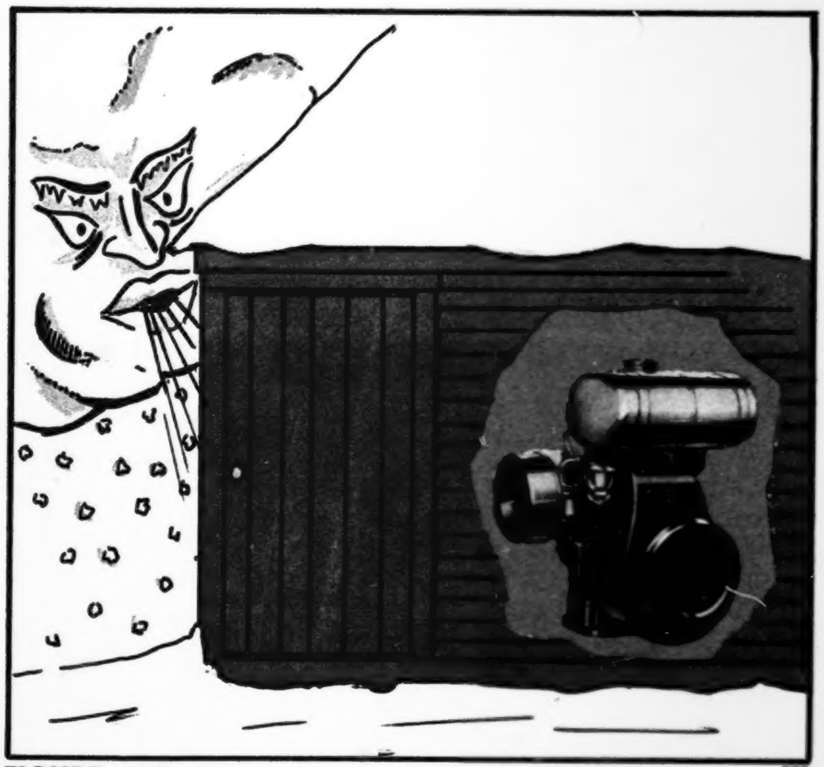


FIGURE 165. Protect your engine during storage. 779

pistons are now made of aluminum, which is not affected by rust. In addition, the trouble of rust flakes accumulating in the fuel tank has been eliminated by several manufacturers. They are now making tanks from plastic and non-corrosive metals. There is, however, still a chance of steel pistons, piston rings, valves and other steel parts becoming corroded during long periods of storage. Manufacturers continue to recommend that you protect your engine with a rust preventive before storing it.

Gum deposits from stale gasoline stored in an engine clog the carburetor and other parts of the fuel system. Gasolines on today's market have gum inhibitors which slow down the formation of gum deposits. Experience has shown, however, that when fuel is drained from the fuel system of a stored engine, it usually starts and runs without difficulty when taken out of storage. This is not always true with engines which have not been properly drained. Many times it is necessary to disassemble and clean the carburetor to remove gum deposits.

Draining the fuel from the fuel system also eliminates a fire hazard from fuel stored in the fuel tank.

Moisture condenses on the outside and in the inside of the engine while it is not being used. This can be harmful to the electrical system even when the remainder of the engine has been protected by a rust preventive. Moisture helps to oxidize the breaker points and electrical connections and insulates them, thus preventing the proper flow of electricity. It may also cause the condenser to become shorted; then the breaker points arc and become pitted.

Moisture will also cause corrosion of steel parts that are not protected otherwise.

Dust and dirt, which may collect on the engine during storage, stick to the cooling fins and will interfere with cooling when the engine is put back into operation. There is also danger of the dirt getting inside the engine when you service it for operation and/or when you remove some part for maintenance or repair. Dirt inside the engine causes rapid wear.

Your engine may be ruined by **physical damage** during storage if you do not put it in a safe place. When stored in a machinery shed or garage, it can be run over by a tractor, truck or other vehicle. Falling objects may break the cooling fins and bend the cylinder baffles. Then the engine will not be cooled properly.

Preparing your engine properly for storage and keeping it in a safe place may also prevent injury to some one who may trip and fall over it. There is also a danger of children and other inexperienced persons starting and operating the engine and equipment and getting hurt. This is especially true with engines on such machines as chain saws, portable generators, small tractors, mowers, and air compressors.

The end of the season is always a good time to check and clean your engine. For one reason, if you find repairs need to be made, you can do them at the time or you can make a note to do them at a more convenient time before the next operating season. A second reason for cleaning is to remove dirt and grime which tend to collect more dirt during storage. Furthermore, you will enjoy taking a clean engine — one that is ready for service — out of storage. It will be almost like having a new engine.

TOOLS AND MATERIALS NEEDED

1. Tools and materials for servicing air cleaners, listed on page 36.
2. Tools and materials for cleaning engines, listed on page 25.
3. Tools and materials for maintaining spark plugs, listed on page 78.
4. Tools and materials for changing crankcase oil, listed on page 66.

5. Crankcase oil
6. Kerosene
7. Oil can (squirt)
8. Rust-preventive, paint and brush
9. Paint, heat resistant enamel
10. Paint brush
11. Plastic sheet for covering engine

PROTECTING THE ENGINE FROM CORROSION, MOISTURE AND GUM DEPOSITS

1. *Operate the engine until it runs out of fuel.*

   This empties the fuel tank and the carburetor.

2. *Check and clean the engine.*

   Refer to "Cleaning Small Engines," page 21.

3. *Check and clean the carburetor air cleaner.*

   It is best to service the air cleaner while you are cleaning the engine. Usually when you take your engine out of storage, it is time to operate it, and you do not wish to be spending time doing more than servicing it with fuel and oil.

   There are two types of cleaners, however, which must be serviced with oil after the engine is taken out of storage. Oil in the **oil-bath type cleaner** may spill when the engine is tilted during operation. It will also collect dust while in storage.

   Oil in the **oiled-filter type cleaner** may settle and not provide adequate protection when you start to operate the engine again.

   NOTE: Be sure to put a tag on engines with this type cleaner to remind you to service the filter element with oil when you take it out of storage.

   Refer to "Servicing Carburetor Air Cleaners," page 32.

4. *Coat the inside of the engine with a rust preventive.*

   There are **two methods** recommended for coating the inside of an engine with rust preventive: (a) *introducing the rust preventive through the carburetor* intake while the engine is running and (b) *pouring the rust preventive into the cylinder* through the sparkplug hole and turning the engine by hand. When it is done properly, the first method distributes the rust preventive better. Most manufacturers, however, recommend the latter method because it is simpler and more likely to be done.

   (a) If you **introduce the rust preventive into the carburetor intake,** proceed as follows:

      (1) *Prepare a mixture of 1/4 cup of crankcase oil and 1/4 cup of kerosene.*

      Use MS or DM oil. They have more rust-preventive additives than ML or MM types.

      (2) *Pour mixture into a squirt can.*

      (3) *Remove the carburetor air cleaner.*

      (4) *Start the engine.*

      This should be done in a clean environment to avoid dirt and dust being drawn into the engine while the air cleaner is removed.

      (5) *Introduce rust preventive mixture into the carburetor air intake with the squirt can (Figure 166).*

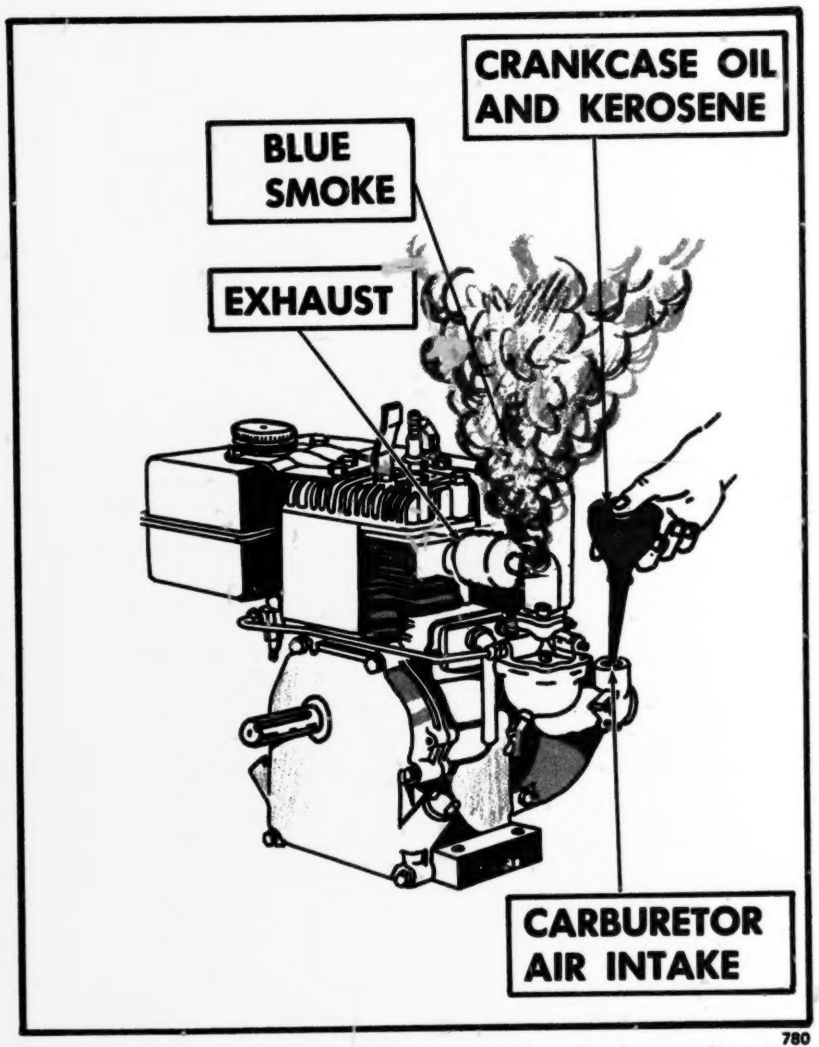


FIGURE 166. Introduce rust preventive in the carburetor intake.

(6) *Stop the engine.*

If your engine is the **4-cycle type,** stop it as soon as you see heavy blue smoke coming from the exhaust.

If your engine is the **2-cycle type,** close both the fuel shut-off valve and the choke valve. Allow engine to run until it stops. This helps lubricate the internal parts of the engine and also drains the carburetor.

(7) *Drain and replace the oil in the crankcase (4-cycle engines) while the engine is warm.*

Any sludge that may have settled out because of your failure to change the oil at the proper time will drain with the oil.

For procedures refer to "Changing the Crankcase Oil (4-Cycle Engines)," page 66.

(8) *Replace the air cleaner.*

Proceed to step 5.

(b) If you **pour the rust preventive through the spark-plug hole,** proceed as follows:

(1) *Fill a squirt can with MS or DM type crankcase oil.*

Do not dilute with kerosene.

(2) *Allow the engine to cool if it has been running.*

(3) *Drain the fuel tank and carburetor.* This prevents fuel from diluting the oil in the cylinder.

(4) *Remove spark plug.*

(5) *Squirt a tablespoon of oil into the cylinder through the spark-plug hole (Figure 167).*

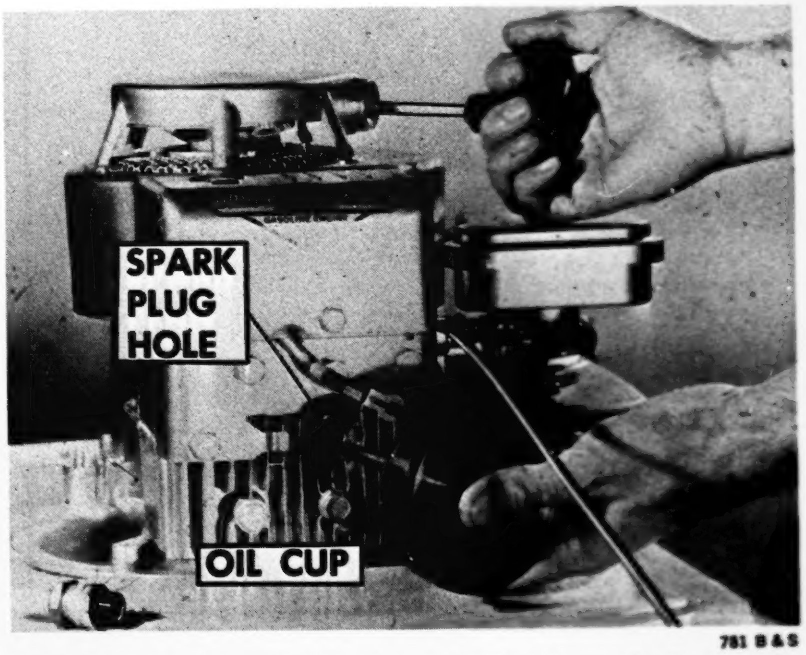


FIGURE 167. Put oil into the cylinder through the spark-plug hole.

(6) *Turn the crankshaft two or three times by hand.*

This distributes the oil on the cylinder wall, around the valves and on the piston rings.

Raise the piston to top position, compression stroke.

Proceed to step 5.

5. *Clean, regap and replace the spark plug.*

   For procedures refer to "Servicing Spark Plugs." page 74.

6. *Drain the carburetor, fuel strainer and fuel tank.*

   (Gasoline forms gum deposits if left in the engine.)

7. *(Pour a tablespoonful of oil into the fuel tank and turn the engine, if possible, until the oil is distributed.)*

   This treatment is to coat the inside of steel tanks to prevent corrosion.

8. *Place piston in top position on compression stroke.*

   At this point both valves are closed, thus protecting the combustion chamber, and most of the cylinder is exposed to the crankcase, which is well oiled.

   Turn crankshaft until you feel the compression pressure; continue until the pressure is released; then stop.

9. *Repaint exposed steel or cast iron surfaces.*

   Use a paint containing a rust inhibitor.

PROTECTING THE ENGINE FROM DIRT AND PHYSICAL DAMAGE

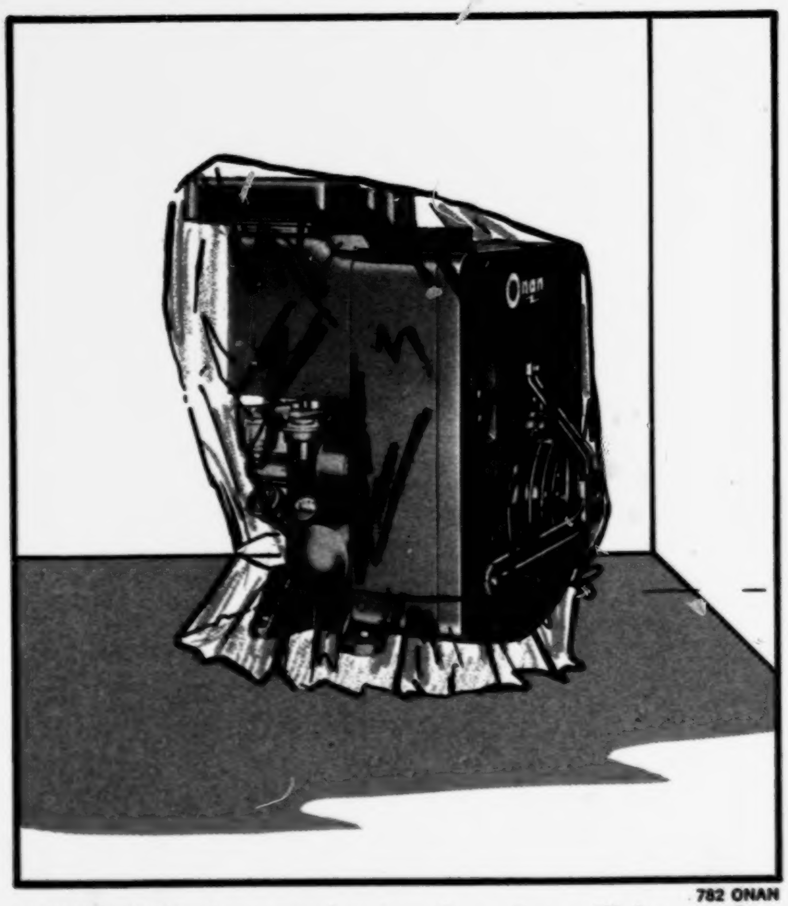


FIGURE 168. A properly stored engine will be ready to operate with a minimum of trouble when you need it again.

1. *Cover engine with a plastic sheet (Figure 168).*
2. *Store in a dry place.*
3. *Place engine in a safe spot for protection against vehicles and/or falling objects.*

OWNER'S ENGINE-INFORMATION FORM

GENERAL INFORMATION:

NAME OF EQUIPMENT (ON WHICH ENGINE IS MOUNTED)

NAME AND ADDRESS OF EQUIPMENT MANUFACTURER

NAME AND ADDRESS OF ENGINE MANUFACTURER

OPERATING POSITION OF CRANKSHAFT: VERTICAL ☐, HORIZONTAL ☐, MULTI-POSITION ☐.

ENGINE CYCLE: 2-Cycle ☐, 4-Cycle ☐.

MODEL NUMBER, OR NAME

SERIAL NUMBER

SPECIFICATION NUMBER

TYPE NUMBER

HORSEPOWER

TYPES OF ACCESSORIES AND MAJOR UNITS:

CARBURETOR AIR CLEANER: Oil bath☐, Oiled filter☐, Dry filter☐.

FUEL STRAINER: Combination screen and sediment bowl☐, Screen inside the fuel tank☐.

CRANKCASE BREATHER: Reed valve☐, Floating disk valve☐.

STARTER: Rope-wind☐, Rope-rewind☐, Wind up☐, Electric, AC☐, Electric, DC☐.

IGNITION SYSTEM: Flywheel magneto☐, External magnet☐, Battery☐.

FUEL PUMP: Mechanically driven☐, Differential pressure driven☐.

CARBURETOR: Float☐, Suction lift☐, Diaphragm☐.

GOVERNOR: Air vane☐, Centrifugal☐.

SERVICE AND MAINTENANCE SPECIFICATIONS:

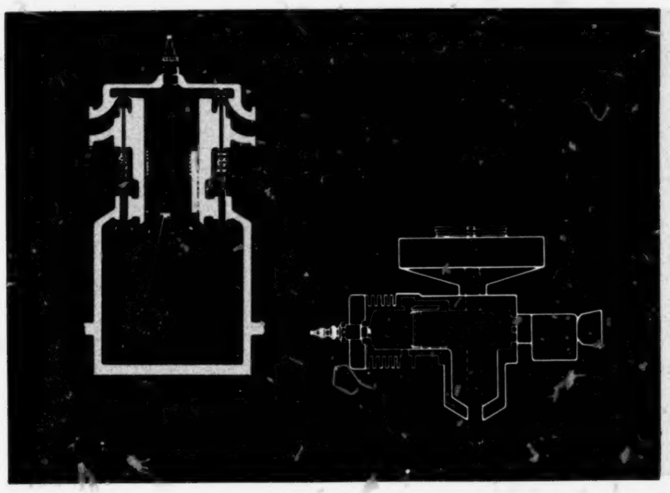
FUEL: Octane number .... Mixture of oil and gasoline (2-cycle) (Amount of oil per gallon of gasoline): 1/4 pint☐, 1/2 pint☐, other............

OIL: SAE grade: 5 W☐, SAE 10 W☐, SAE 20 W☐, SAE 30☐, SAE 10 W-30☐. Classification: ML☐, MM☐, MS☐.

TYPE OF SPARK PLUG: ....

Gap setting: .020", .025", Other ....

IGNITION BREAKER-POINT GAP: .012"☐, .015"☐, Other ....



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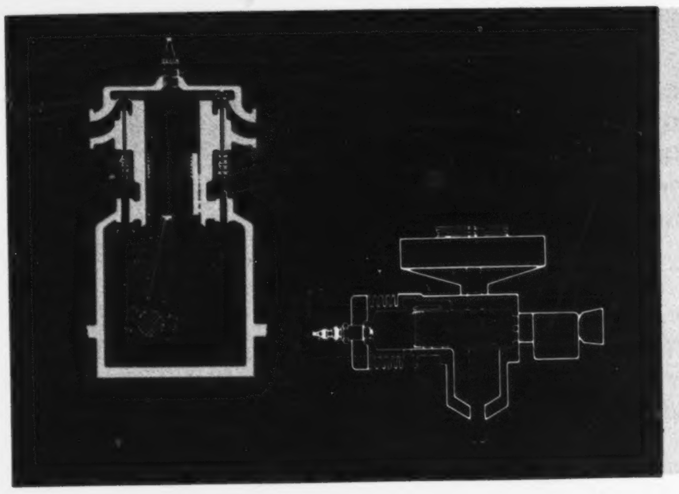

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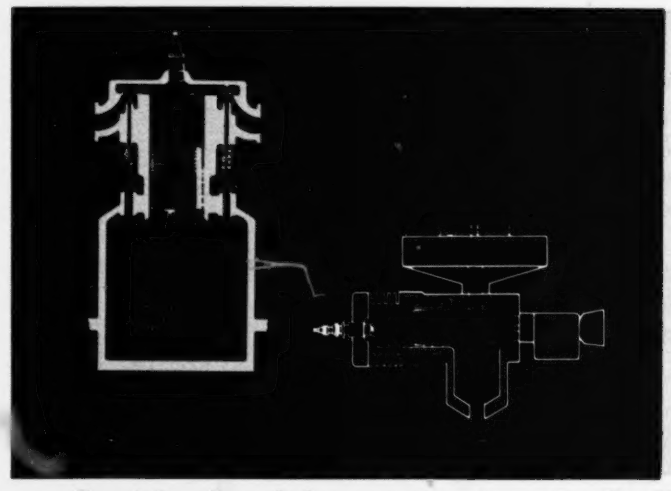

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